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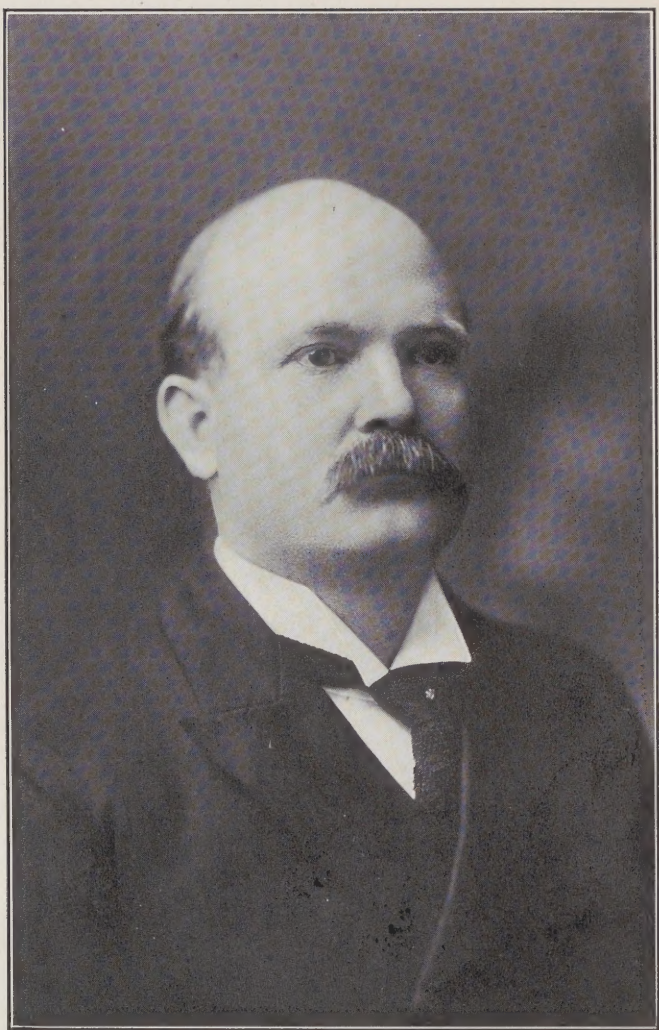
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THE
Key to Sex Control



Percy J. McGrath, M.D.

THE
Key to Sex Control

OR

The Cellular Determination
of Sex *and* The Physiological
Laws Which Govern Its Control

BY

PERCY JOHN McELRATH, M.D.

212295

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NEW YORK CITY
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PREFACE.

THE present volume is the outcome of several years of study and experiment in the broad field of cell-life. The author has long entertained the opinion that the beautiful axiom, THE UNIVERSE IS GOVERNED BY LAW, applies not only to the suns and planets in their courses, but, with equal force and completeness, to the complex phenomena of the minute cells that combine to form the bodies of men and animals. He believes that the problems of heredity, sex, and development, which so fundamentally affect the human race and which have so long baffled investigators, are based on invariable natural laws, a proper knowledge of which will have a far-reaching effect on the future development of the human race.

The famous aphorism of Socrates, "Know thyself," applies especially to man as a complex organism, and with peculiar force to his sacred sexual relations in the propagation of his species. False modesty has too long been the handmaid of ignorance in the most important and far-reaching duty of human life, and it is high time that the scientist should realize that the improvement and development of the race lie within his domain and that all other biological laws dwindle into insignificance in comparison with this great problem.

Before Intelligence, in the form of man, made its appearance on the earth, the evolution of life-forms had proceeded without apparent direction or reason; the multiplication and variation of species were stupendous. Most of these various forms are known to-day only as fossils in the graveyard of Evolution; many, however, have persisted and comprise the useful and useless animals that inhabit the earth with man. Few, if any, new species have originated since *Homo sapiens* appeared on the scene, and many, doubtless, may attribute their extinction to his interference. As the descendants of this wonderful primate gradually extend their dominion over the earth, the face of the planet is changed in many respects, many of the forces of nature are harnessed to do man's bidding and even evolution itself is made, in some degree at least, to serve his wants. Many animals that are useless or malignant have been exterminated or greatly reduced in number and range; others that are useful to man have been protected, increased in number, and improved.

Only within the last hundred years, however, have the great laws of natural selection and survival of the fittest been understood, with the result that man is beginning to supplement *natural* selection with *intelligent* selection. By proper selection and breeding, many fruits, grains, and vegetables have been greatly improved, new kinds have been produced and even useless plants have been changed into useful food plants. Animals have been domesticated and, by selection, have been improved and made to serve man in various ways. The work of such

men as Burbank, Gregon Mendel, Charles Darwin, and others is eloquent of a glorious future, in which man, brought to a full realization of the possibilities of intelligent selection and breeding, will not only bend his energies to improve plants and animals, but will also undertake that greater and nobler work of improving the human species.

While the prevention of breeding by the deformed, the criminal, and the degenerate may not be possible for centuries to come, it *is* possible to teach the people the fundamental facts and laws that govern the reproduction of the species and to publish, so that all may know, those conditions of health, nutrition, environment, and physical fitness that control and determine this all-important phenomenon. There is no biological process that approaches in importance that by means of which human life is propagated; and none about which greater ignorance prevails. It concerns not only the continuance of the race on the planet, but, very largely, the character of the race. Consequently, every individual who expects to become a father or a mother should know, to the fullest extent, the anatomy of the parts concerned, the biological and physiological laws governing them, and, especially, the rules and circumstances under which the finest specimens of offspring may be produced.

The author firmly believes that a full and complete knowledge of the conditions under which insemination, fertilization, and embryonic development take place will enable the scientist to solve the ultimate problems of inheritance and sex, which are acknowledged to be *cell-*

problems. He offers the present volume, therefore, with the belief that it will be a material step toward the solution of these problems and that it will stimulate others to take up this most important but neglected branch of research. At the present stage of his investigations, the author does not claim that sex-control can be rendered absolute, for conditions cannot always be made ideal, but he does assert that sex can be predetermined in a majority of cases in mammals, birds, fishes, and reptiles.

Believing that Science will improve and perfect the human species, as it has improved other species, and with an abiding faith in the future of the race that has weighed suns and isolated cells, the author submits his work to the serious consideration of a candid world.

Grateful appreciation is due to Lieut. Riley E. Scott for his aid in preparing the chapter on history. The illustrations, for the most part, are the work of Mr. F. A. Deck, whose efficient service has materially enhanced the value of the book.

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November, 1911.

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The Key to Sex Control

CHAPTER I.

HISTORY OF SEX DETERMINATION.

THE problem of sex determination is probably a very old one. In fact, there are many rules and regulations in the laws of early civilizations, especially in the Mosaic laws of the Hebrews, which would lead us to believe that this important question was considered in those early times. It is reasonable to suppose that, in ancient times, when the security and welfare of the people depended almost altogether on the soldiery, the problem of sex-control received serious consideration by the wise men of the court, and that the laws laid down by them were of such a nature as to give the greatest chances of male-production. Not only were soldiers wanted, but male heirs to the throne were necessary, a thing very close to the heart of the monarch.

It is only in modern times, however, that any serious steps have been taken toward the solution of the problem of sex-control; and only since the renowned discovery of the cell by Schleiden and Schwann, in 1838-39, that any real scientific work has been done in this direction.

In fact, up to the present time, the work done on this problem is totally unworthy of its vast importance and far-reaching possibilities.

Investigators in this line of research may be divided into two groups: those who believe that external conditions determine the sex and those who maintain that the sexual cells differ from the first. Of these, workers in the first group were the earlier and, until recently, predominant; but, at present, scientists generally recognize the theory that sex determination depends primarily upon the sexual cells and not upon external conditions affecting the embryo. It will be seen that many conflicting theories have been advanced, some fanciful, some ingenious, but that no generally accepted laws have been laid down.

Among the early investigators was Charles Darwin, who reviewed the evidence obtainable in his time and expressed the belief that the tendency to produce male or female offspring was inherited and that by a process of natural selection it was adjusted to the needs of the species, but he did not discuss the nature of the determining factors. G. Canestrini was of the opinion that sex is determined by the number of spermatozoa that enter the ovum, but we now know that only one spermatozoön normally conjugates with an ovum. Professor Thury and C. Düsing expressed opinions that ova fertilized soon after ovulation give rise to females, while those impregnated later produce males. Convincing evidence exists as to the effect of delay in fertilization. J. D. Hofacker, in 1823, and M. O. Sadler, in 1830, collected a large series of statistics from which they drew the conclusion that, when the male parent is older and

more mature, more males are produced. Some investigators have claimed that the sex of the offspring tends to be that of the less vigorous parent; while others have urged that the most vigorous parent gives his or her sex to the progeny. A large number of careful investigators have been led to believe that conditions of nutrition play a large part in determining sex, but in nearly every case other observers have obtained conflicting results or have drawn different deductions from the facts. E. Yung, from a number of interesting experiments, found that when tadpoles were reared under normal conditions, the proportion of male to female was about 43 : 57; but that when a flesh diet was provided, the percentage of females was greatly increased. Mrs. Treat showed that starved caterpillars turned into males, and E. Maupas took certain rotifers and demonstrated a relation between abundant nutrition and an excessive production of females. P. Gedds and J. A. Thompson (1889) asserted that factors external to sexual cells had a predominating importance in the determination of sex. They conceived of sex as an effect of an alternating rhythm of anabolism and katabolism to be observed throughout the living world, and supposed that femaleness was an expression of the anabolic or constructive processes of living matter, whilst maleness represented the katabolic, destructive, or liberating processes. Professor Thompson, in a later work (1907), however, practically withdrew his theory. Dawson, in his work on sex determination, has suggested that the ova from the right ovary produce male and those from the left, female, and reported many cases of male-production from the right ovary and some female from the left. This theory,

however, is disproved by the fact that there are cases on record where women, after having one ovary removed, have produced both sexes. The author personally knows of a case in which a woman had one ovary removed and subsequently gave birth to a girl and two years later produced a fine boy. It is probable that the arteries to the right ovary are just a little larger than those to the left, and, in that event, a Graafian follicle would reach maturity sooner in it than in the left and this would increase the chance for male-production from early insemination after menstruation. It is also a fact that women lie on the right side more than on the left and, when a Graafian follicle matures in the right ovary, the ovum is assisted to the fimbriated extremity of the Fallopian tube by gravity, where it is delivered to the spermatozoön before it has become female-producing. When the Graafian follicle is matured in the left ovary and the woman lies on the right side after insemination, external migration of the ovum is almost sure to follow and, in that event, more time is consumed by the ovum in reaching the fimbriated end of the oviduct and the spermatozoön has had more time to become female-producing.

Investigators in the second group—those who believe that sex is predetermined in the sexual cells—have been less numerous than those in the first group, but they occupy more tenable ground. In fact, all true progress toward the discovery of the factors which determine sex became possible only after the enunciation of the cell-theory by Schleiden and Schwann. A long list of subsequent investigators have placed the cell-theory upon a firm basis and have done much to elucidate the mysteries

of heritage and sex. Among the most important may be mentioned Kölliker, who, in 1841, demonstrated that the spermatozoa are not parasites but are cells generated in the testes; and Schweigger, Seidel, and La Valette St. George who, in 1865, proved that the spermatozoön contains not only a nucleus, as Kölliker believed, but also cytoplasm. Not less important was the discovery of Oscar Hertwig that fertilization of the ovum is accomplished by its union with one spermatozoön, and only one. In 1855, Virchow established the universality of cell-division, expressed in his since famous aphorism, "omnis cellula e cellula." These and other discoveries demonstrated that the cell is the basis of life and led Wilson to remark that "a single cell may contain within its microscopic compass the sum total of the heritage of the species." Among workers in the field of sex determination under the second group, the names of Gregon Mendel and E. B. Wilson stand out preëminent. Gregon Mendel was born in 1822, from peasant parentage, and later became a monk and abbot of Brünn. In 1865, he published an account of his experiments, but these valuable writings were not appreciated until recently and now bid fair to give him a name in the biological world second only to that of Darwin. From numerous experiments carried on through a long period of years, he discovered and elaborated many of the physiological processes of heredity upon which later biologists have largely depended. A brief description of what is now called Mendelism is not possible, for the reason that his experiments were extensive and many of his deductions involved; but while many of his theories are more ingenious than conclusive, his work is generally recognized

as having been of a very high order. E. B. Wilson (1909) published a work which has a very important bearing on sex determination. In it he gives a full discussion of the accumulated facts concerning the existence of different kinds of sexual cells and the nuclear changes which occur in ovogenesis and spermatogenesis. He considers over a hundred different species of insects, myriapods, and arachnids in which two kinds of spermatozoa are produced. These spermatozoa are formed in pairs, and the mother cell which gives rise to each pair exhibits paired chromosomes, one member of each pair passing into each spermatozoon. The mother cell contains also an impaired element, consisting in its simplest form of a single large chromosome, which Wilson terms the "X" element. This "X" element passes into one or the other of the spermatozoa, from which it results that spermatozoa of two kinds are formed in equal numbers, the difference being the presence or absence of the "X" element. Eggs fertilized by spermatozoa containing the "X" element become females; those without it, males. Thus the "X" element becomes the index of sex.

The author, in the present volume, claims that neither the fertilizing cell nor the egg cell has any sex tendency, *per se*, but that sex is determined solely by the manner and completeness of entrance of the spermatozoön into the ovum. If the sperm cell enters entirely into the cytoplasm of the egg, a male is produced; if the entire cell does not enter the egg, a female is produced; and if two or more cells enter the ovum, an abnormality is produced.

CHAPTER II.

THE MALE ORGANS OF GENERATION.

THE human male generative organs consist of two testicles, vesiculæ seminales, penis, and the prostate gland which is generally included among these organs. The testicles generate and develop the spermatozoa which are transmitted from the seminiferous tubules to the vesiculæ seminales by the vas deferens. The vesiculæ seminales receive and retain the semen until it is ejected by orgasm. The penis is an erectile organ through which the semen as well as the urine is discharged. The function of the prostate gland is not clearly understood.

Development of the Generative Organs.—The first rudiments of the organs of reproduction are essentially the same in the two sexes; they consist of the genital ridge (Fig. 1), situated on the mesial side of each Wolffian body, and from it are developed the testicles in one sex, and the ovaries in the other. As the embryo grows, the ridge gradually becomes pinched off from the Wolffian body, with which it is at first continuous, though it still remains connected to the remnant of this body by a fold of peritoneum, the mesorchium. About the seventh week the distinction of sex begins to be perceptible, in that the epithelium on the genital ridge, called “germ-epithelium,” though in general it has a tendency to become columnar, has its cells, on the whole, flatter and smaller in the male than in the female.

Development of the Male Organs.—The tubuli seminiferi of the testicle appear at an early period. It is believed that they are formed by the extension of epithelial cells from the surface of the genital ridge into its blastema; rows of cells are thus developed which become the lining cells of the seminal ducts. In some animals (*e.g.*, reptiles) the segmental tubes of the Wolffian body (Fig. 2, *w*) have been found to extend

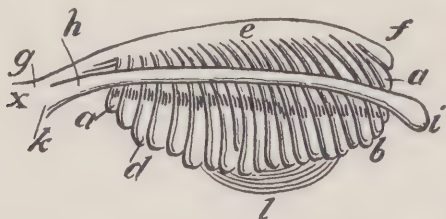


FIG. 1.—ENLARGED VIEW FROM THE FRONT OF THE LEFT WOLFFIAN BODY BEFORE THE ESTABLISHMENT OF THE DISTINCTION OF SEX. (From Farre, after Kobelt.)

a, a, b, d, Tubular structure of the Wolffian body; *e*, Wolffian duct; *f*, its upper extremity; *g*, its termination in *x*, the urogenital sinus; *h*, the duct of Müller; *i*, its upper, still closed, extremity; *k*, its lower end, terminating in the urogenital sinus; *l*, the mass of blastema for the reproductive organ, ovary or testicle.

into the body of the testis and to form the tubes of this organ, which becomes lined with cells derived from the germ-epithelium; and it is probable that a similar process takes place in birds and mammals.

In the male sex, the Müllerian ducts (Fig. 2, *m m*) disappear with the exception of their lower ends. These unite in the middle line, and open by a common orifice into the urogenital sinus (Fig. 2, *u g*). This constitutes the utriculus hominis or sinus prostaticus. Occasionally, however, the upper end of the duct of Müller remains visible in the male, constituting the little pedunculated body called the hydatid of Morgagni, sometimes found

in the neighborhood of the epididymis, between the testes and globus major.

The head of the epididymis, its canal, the vas deferens, and the ejaculatory duct are formed from the canals and

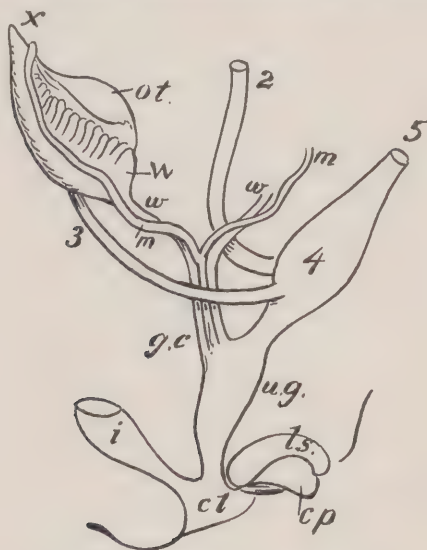


FIG. 2.—DIAGRAM OF THE PRIMITIVE UROGENITAL ORGANS IN THE EMBRYO PREVIOUS TO SEXUAL DISTINCTION.

The parts are shown chiefly in profile, but the Müllerian and Wolffian ducts are seen from the front. 3, Ureter; 4, urinary bladder; 5, urachus; *ot*, the mass of blastema from which ovary or testicle is afterward formed; *w*, right Wolffian body; *x*, part at the upper apex from which the coni vasculosi are afterward developed; *w*, *w*, right and left Wolffian ducts; *m*, *m*, right and left Müllerian ducts uniting together and with the Wolffian ducts in *g.c.*, the genital cord; *u.g.*, sinus urogenitalis; *i*, lower part of the intestine; *cl*, common opening of the intestine and urogenital sinus; *cp*, elevation which becomes clitoris or penis; *ls.*, ridge from which the labia majora or scrotum is formed.

duct of the Wolffian body (Fig. 2, *w*). One or more of the tubes of the Wolffian body form the vas aberrans and a structure described by Giraldès, and called after him "the organ of Giraldès," which bears a good deal

of resemblance to the organ of Rosenmüller in the other sex. It consists of a number of convoluted tubules lying in the cellular tissue in front of the cord and close to the head of the epididymis.

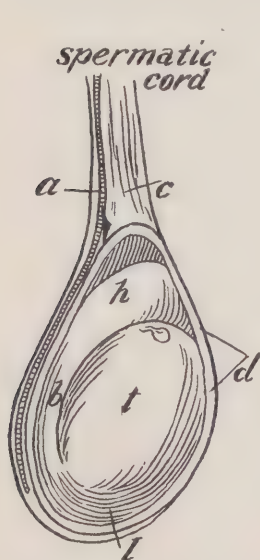


FIG. 3.—THE TESTIS *in situ*; THE TUNICA VAGINALIS HAVING BEEN LAID OPEN.

a, Artery of cord; *c*, cremaster; *d*, tunica vaginalis parietal layer; *t*, testis; *h*, head; *b*, body; *l*, tail.

Descent of the Testes.—At

an early period of foetal life the testes are placed at the back part of the abdominal cavity, in front and below the kidneys, behind the peritoneum. At about the third month of foetal life, the gubernaculum testis (Fig. 1, *l*) makes its appearance. This structure is a slender band which extends from the internal ring to the epididymis and body of the testicle, and passes upward in front of the kidney toward the diaphragm. As development advances the testicle is so covered by the peritoneum as to form a mesentery, the mesorchium, which also encloses the gubernaculum and has two folds, one above and one below the testicle. The one above the

testicle ultimately contains the spermatic vessels; the one below contains the lower part of the gubernaculum, which has developed into a thick cord; it ends below at the internal ring in the processus vaginalis, which is now in the inguinal canal. The lower end of the gubernaculum becomes a thick cord by the fifth month, while the upper

part has disappeared. The gubernaculum extends to the inguinal canal at about the sixth month, and later to the bottom of the scrotum. The processus vaginalis projects



FIG. 4.—THE TESTICLE, AND THE ELEMENTS OF THE SPERMATIC CORD.

A, The vas deferens; *B*, spermatic artery; *C*, spermatic veins. (Campbell.)

itself downward into the inguinal canal, where it gradually forms a cul-de-sac, which ultimately reaches the bot-

tom of the scrotum. The cul-de-sac is invaginated by the testicle, and, as the body grows, the gubernaculum does not grow commensurately with the growth of the other parts. The testicle, being attached to the bottom of the scrotum by the gubernaculum, is prevented from rising with the body as it grows, and thus is drawn into the inguinal canal and ultimately into the scrotum. At the eighth month the testicle has reached the scrotum. The processus vaginalis for a short period communicates at its upper extremity with the peritoneal cavity. The upper part of the pouch becomes closed at about the time of birth, and this obliteration extends downward to within a short distance of the testicle. The process of peritoneum surrounding the testis, which is now cut off from the general peritoneal cavity, constitutes the tunica vaginalis. A small cord in the female, corresponding to the gubernaculum in the male, descends to the inguinal region, and later forms the round ligament of the uterus. A process of peritoneum accompanies it along the inguinal canal, analogous to the processus vaginalis in the male; it is called the canal of Nuck.

The testes are suspended in their tunics (Figs. 3, 4) by the spermatic cord. Each gland is of an oval form, compressed laterally, and has an oblique position in the scrotum. The anterior border and lateral surfaces, as well as both extremities of the organ, are convex, free, smooth, and invested by the tunica vaginalis. The posterior border, to which the cord is attached, receives only a partial investment from the membrane. Lying along this posterior border is a long, narrow, flattened body, named the epididymis, from its relation to the testis (Fig. 3). It consists of a central portion, or body;

an upper enlarged extremity, the globus major, or head; and a lower pointed extremity, the tail, or globus minor. The globus major is intimately connected with the upper end of the testicle by means of its efferent ducts, and the globus minor is connected with its lower end by cellular tissue and a reflection of the tunica vaginalis. The outer surface and upper and lower ends of the epididymis are free and covered by serous membrane; the body is also completely invested by it, excepting along its posterior border. The epididymis is connected to the back of the testis by a fold of serous membrane. Attached to the upper end of the testis or to the epididymis are one or more pedunculated bodies. One of them is pretty constantly found between the globus major of the epididymis and the testicle, and is believed to be the remains of the upper extremity of the Müllerian duct (Fig. 2, *mm*). It is termed the hydatid of Morgagni. The average dimensions of each testis are from one and a half to two inches in length, one inch in breadth, and an inch and a quarter in the antero-posterior diameter, and the weight varies from six to eight drachms, the left testicle being a little larger.

At an early period of foetal life the testes are contained in the abdominal cavity, behind the peritoneum. Before birth they descend to the inguinal canal, along which they pass with the spermatic cord, and, emerging at the external abdominal ring, they descend into the scrotum, becoming invested in their course by numerous coverings derived from the serous, muscular, and fibrous layers of the abdominal parietes, as well as by the scrotum. The coverings of the testes are: the

Skin;

Dartos, scrotum;

Intercolumnar, or external spermatic fascia;

Cremasteric fascia;

Infundibuliform, or fascia propria (internal spermatic fascia);

Tunica vaginalis;

all of which support and protect the testes. The scrotum is a cutaneous pouch which contains the testes and a part of the spermatic cords. The median line, or raphe, divides it laterally into halves. Its external aspect varies under different circumstances; thus, under the influence of warmth and in old and debilitated persons it becomes elongated and flaccid, but under the influence of cold and in the young and robust it is short, corrugated, and closely applied to the testes.

The scrotum consists of two layers, the integument and the dartos.

The integument is very thin, brownish in color, and thrown into folds or rugæ in its normal condition. It is beset with thinly scattered short hairs, the roots of which may be seen through the skin, and is provided with sebaceous glands, the secretion of which has a peculiar odor.

The dartos is a thin layer of loose, very vascular tissue endowed with contractility from the smooth muscular fibres it contains. It forms the proper tunic of the scrotum, and is continuous, around the base of the scrotum, with the two layers of the superficial fascia of the groin and perineum, and sends inward a distinct septum, septum scroti, which divides it into two cavities for the two testes, the septum extending between the

raphe and the under surface of the penis as far as its root. The dartos is closely united to the skin externally, but connected with the subjacent parts by delicate areolar tissue, upon which it glides with the greatest facility.

The intercolumnar fascia is a thin membrane which is prolonged downward around the surface of the cord and testis. It is separated from the dartos by loose areolar tissue, which allows considerable movement of the latter upon it, but it is intimately connected with the succeeding layers.

The cremasteric fascia consists of scattered bundles of muscular fibres, which are continuous with the lower border of the internal oblique muscle of the abdomen.

The fascia propria is a thin membranous layer which loosely invests the surface of the cord. It is acquired during the descent of the testis in the fœtus.

It is very evident from the anatomy of the tunics of the testes, as shown in the abundance of loose areolar tissue, that nature has provided well against their compression. This protection is so perfect that it is difficult to grasp and hold the normal testicle between two fingers. Thus in the free and easy gliding movement of the testes within the tunics the male is protected against their compression and the consequent pain and the premature dislodgment (before maturity) of the spermatozoa from the mother cells. The testicle of a blacksmith while shoeing horses is subject to more or less compression, which produces the premature rupture of the spermatozoa from the mother cells, and this probably explains the high mortality in their male children (see pages 67, 68, 69).

Structure of the Testis.—The testis is enclosed in a strong capsule (Fig. 5, *c*), the tunica albuginea. This is a dense, unyielding, fibrous membrane, of white color and of considerable thickness. which immediately invests the

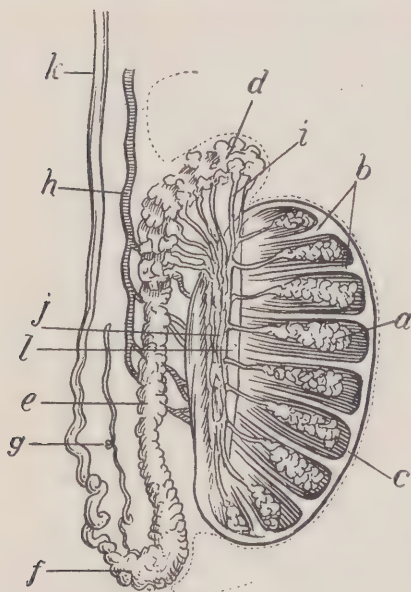


FIG. 5.—VERTICAL SECTION OF THE TESTICLE, TO SHOW THE ARRANGEMENT OF THE DUCTS.

a, Lobule; *c*, tunica albuginea; *b*, its septa; *d*, globus major; *e*, body of epididymis; *f*, globus minor; *g*, vas aberrans; *h*, spermatic artery; *i*, vasa efferentia; *j*, rete testis; *k*, vas deferens; *l*, mediastinum.

soft substance of the testis and preserves the form of the gland. It is composed of bundles of fibrous tissue which interlace in every direction. The outer surface is covered by the tunica vaginalis, except along the posterior border of the testis, where the spermatic vessels pass through and the two extremities of the epididymis are attached.

In the interior (Fig. 5, *b*), the fibrous tissue of the tunica albuginea is prolonged from the posterior border for a short distance into the substance of the gland, so as to form within it an incomplete vertical septum, known as the corpus Highmori and named by Astley Cooper mediastinum testis. It extends from the upper nearly to the lower end of the gland, and it is wider

above than below. The firm tissue of which it is composed is traversed by a network of seminal ducts (Fig. 5, *a*), and by the larger blood-vessels of the gland, which are lodged in channels formed in the fibrous tissue.

From the front and side of the corpus Highmori numerous slender fibrous cords and imperfect septa of connective tissue are given off in radiating directions, and are attached by their outer ends to the internal surface of the tunica albuginea at different points, thus incompletely dividing the glandular substance into lobules. According to Kölliker, smooth muscular fibres are prolonged upon these septula. The whole internal surface of the tunica albuginea is covered by a multitude of fine blood-vessels, which are branches of the spermatic artery and veins, and are held together by a delicate areolar web. Similar delicate ramifications of vessels are seen on the various fibrous offshoots of the mediastinum, upon which the blood-vessels are thus supported in the interior of the gland.

The Seminiferous Tubules.—The glandular substance of the testis which is included in the fibrous framework formed by the albuginea (Fig. 5, *a*), the mediastinum, and the trabeculæ, is a mass of convoluted tubules known as the *tubuli seminiferi*, which are somewhat loosely bound together by areolar tissue into the lobes or lobules above mentioned. Of these lobes there are some one hundred to two hundred (Krause) or more; they are of unequal size, the middle ones being the larger, and are imperfectly separated from one another, the septa being incomplete. In each lobe are two, three, or more seminiferous tubules closely convoluted, and here and there branched, especially at their anterior or distal

extremity, where, in a cortical zone near the albuginea, they are stated to communicate frequently laterally with one another. "It is not difficult to unravel the tubules for some distance, for their walls are moderately strong, and their diameter (0.2 mm.) large compared with those of other tubular glands, such as the kidney" (Quain). The thickness of the walls just referred to is necessary to prevent the escape of the spermatozoa from the tubes. The movement of the spermatozoön is comparatively slow and weak while it is in the seminiferous tubule, but becomes more rapid and powerful as it approaches the vesiculæ seminales, which are reached by its inherent power. On section of a seminiferous tubule, many spermatozoa are seen, but only those fully matured are able to move.

The length of the seminiferous tubules has been variously estimated by different authors. Lauth has estimated their length to be on an average rather greater than two feet, and their number between eight hundred and nine hundred, while Munro has estimated their total number to be three hundred, and the length of each is about sixteen feet. The diameter varies from $\frac{1}{200}$ to $\frac{1}{150}$ of an inch. The tubuli are pale in color in early life, but in old age they acquire a deep yellow tinge. They have a smooth contour, but this is interrupted at intervals by small dilatations, which are more numerous near the commencement of a tubule than near its termination. The walls of the seminiferous tubules are composed of several layers of flattened cells. Of these only the innermost layer is complete, being formed of epithelioid cells closely united edge to edge into a basement membrane. This is strengthened by the other layers, which, however,

exhibit intervals between the flattened cells which compose them, these intervals becoming very marked in the outermost layers. In consequence of their being thus formed of several layers, the walls of the tubules have a concentrically striated appearance in cross-section. The tubules are occupied by an epithelium which consists of several irregular layers of cells, among which the seminal filaments or spermatozoa may be observed in different stages of development (Fig. 6). In different tubules of the same testis and even in parts of the same tubule the state of development of the spermatozoa may be various, and the epithelium presents corresponding differences, both in the number of its layers and in the state of the cells.

Structure of the Seminiferous Tubules.—The seminiferous tubules are formed of a thick basement-membrane, and contains several layers of epithelial cells. Of these layers, the first, which is composed of the outer layer or lining cells (spermatogonia), forms the outermost zone. They are clear cubical or somewhat flattened cells, disposed in a single regular layer upon the basement membrane of the tubule (Fig. 6, z'). In some tubules one of these cells may here and there be seen to be elongated and to project between the cells of the next zone, where it comes into connection with a group of developing spermatozoa. Indications of cell division are also met with in this layer (Fig. 6, y). The enlarged cells of this layer are the cells of Sertoli (Fig. 6, z' , z'').

Next to this lining epithelium is a zone of larger cells, spermatocytes (Fig. 6, y). The nuclei of these cells are usually in some stage of hetero- or homo-typical mitotic division; these cells may be two or three deep (Fig. 6, z).

Next to these, and most internal, are to be seen in some tubules (Fig. 6, *y* and *x*) a large number of small protoplasmatic cells with simple spherical nuclei (spermatid, Fig. 6, *x*). In other tubules, the spermatids are elongated, and the nucleus is at one end, and in others again these elongated cells are converted into evident spermatozoa, which lie in groups of four to eight, or sixteen, "and sometimes as many as twenty are attached to a mother cell" (Kölliker). Their heads are attached to one of the deeper cells of the lining epithelium (Sertoli cells), and their tails project into the lumen of the tubule. As they mature the mother cell becomes elongated, which causes them gradually to shift altogether toward the lumen; when the attachment to the mother cell is severed, they become free. During the time that this crop of spermatozoa has been forming, another set of spermatocytes has been produced by the division of the spermatogonia, and on discharge of the spermatozoa the process is repeated.

Spermatogenesis.—According to Schafer, who is quoted by Quain, the spermatozoa are developed from the small cells (spermatids) which form the innermost stratum of the seminal epithelium, and these are themselves produced by the division of the large spermatocytes of the second layer. It is probable that fresh spermatocytes are formed by division of the lining epithelium-cells or spermogons. The cycle of changes, therefore, which takes place is as follows: 1. Division of a lining epithelium-cell or spermogon into two, one of which grows larger (growing cells of H. H. Brown), becomes a spermatocyte, and passes into the second layer, while the other remains in the first layer; 2. Di-

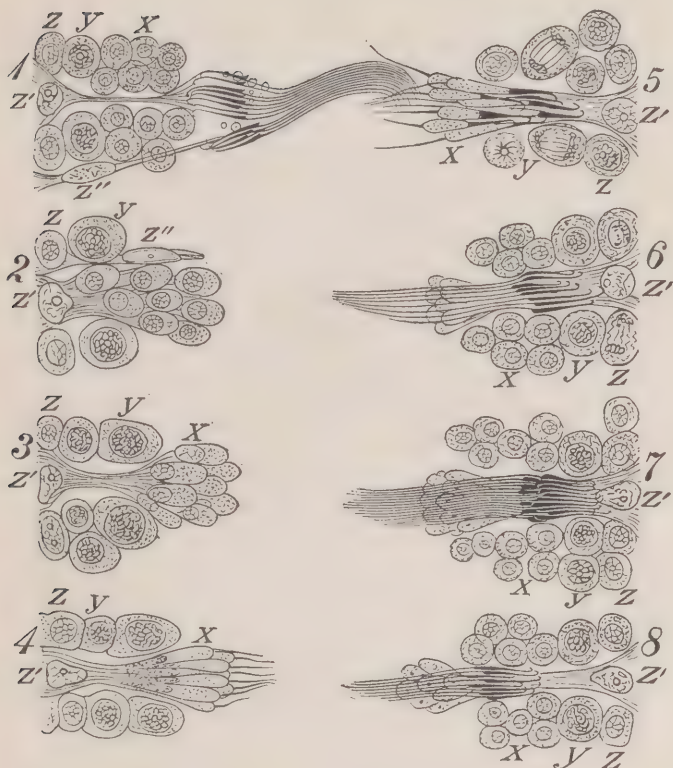


FIG. 6.—DIAGRAM EXHIBITING THE CYCLE OF PHASES OF SPERMATOGENESIS (RAT).

z, Lining epithelium-cells are spermatogonia, seen dividing in 6; *z'*, *z''*, Sertoli cell; *y*, spermatocytes, with skein-like nuclear filaments. These cells are seen actively dividing in 5. *x*, Spermatids, forming an irregular column or clump in 6, 7, 8, and 1, and connected to an enlarged Sertoli cell, *a'*, of the lining epithelium in 2, 3, 4, and 5. In 6, 7, and 8 advanced spermatozoa of one crop are seen between columns of spermatids of the next crop.

vision of the spermatocyte; 3. Further division of the daughter-spermatocytes thus produced. The four cells (spermatids) which result from this double division possess only one-half the somatic number of chromosomes in their nuclei, "reduction" having been effected in the final cell-division by which the spermatids are produced (Fig. 7). Elongation of the spermatids and their gradual conversion into spermatozoa follow. As they undergo this conversion their grouping becomes more evident, and each group is found to be connected with a cell of Sertoli (Fig. 6, *z'*), which undoubtedly ministers to their nutrition.

The tubules are enclosed in a delicate plexus of capillary vessels and are held together by an intertubular connective tissue which presents large interstitial spaces lined by endothelium, and these are supposed to be the beginning of the lymphatic vessels of the testis. In the free spaces of the lobules the tubuli become less convoluted, assume a nearly straight course, and unite together to form from twenty to thirty larger ducts, about $\frac{1}{30}$ of an inch in diameter, and these, from their straight course, are called tubuli recti.

The tubuli recti enter the fibrous tissue of the mediastinum and pass upward and backward, forming, in their ascent, a close network of anastomosing tubes, which are merely channels in the fibrous stroma, as they have no proper walls; this network constitutes the rete testis (Fig. 5, *j*). At the upper end of the mediastinum the vessels of the rete testis terminate in from twelve to twenty ducts, the vasa efferentia (Fig. 5, *i*), which perforate the tunica albuginea and carry the seminal fluid from the testis to the epididymis (Fig. 5, *e*). Their

course is at first straight; they then become enlarged and exceedingly convoluted, and form a series of conical masses, the *coni vasculosi*, which together constitute the *globus major* of the epididymis. Each cone consists of a single convoluted duct from six to eight inches in

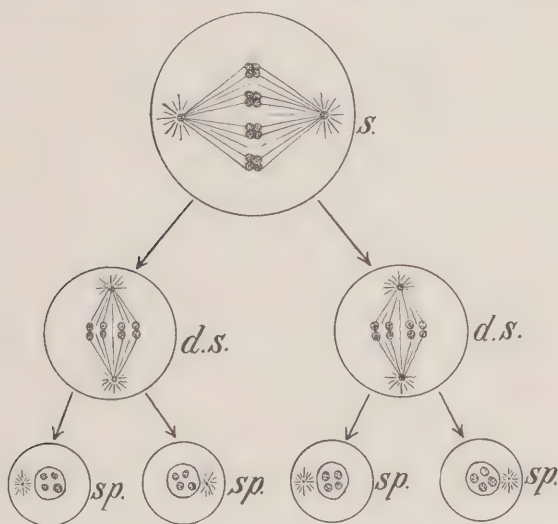


FIG. 7.—DIAGRAM SHOWING THE REDUCTION OF THE CHROMOSOMES DURING SPERMATOGENESIS.

s., Spermatocyte of the first order; *d.s.*, the daughter spermatocytes; *sp.*, spermatids.

length, the diameter of which gradually decreases from the testis to the epididymis. Opposite the base of the cones the efferent vessels open at narrow intervals into a single duct, which constitutes, by its complex convolutions, the body and *globus minor* of the epididymis. When the convolutions of this tube are unravelled, it measures upward of twenty feet in length, and increases in breadth and thickness as it approaches the vas

deferens. The convolutions are held together by fine areolar tissue and by bands of fibrous tissue.

The vasa recta are of smaller diameter than the seminal tubes, and have very thin parietes. They, as well as the channels of the rete testis, are lined by a single layer of flattened epithelium. The vasa efferentia and the tubes of the epididymis have walls of considerable thickness, on account of the presence in them of muscular tissue, which is arranged principally in a circular manner. These tubes are lined by columnar ciliated epithelium, which is motionless in the human species.

The vas deferens is the continuation of the epididymis (Fig. 5, *k*). Commencing at the lower part of the globus minor (Fig. 3, *l*), it ascends along the posterior border of the testis and the inner side of the epididymis, and along the back part of the spermatic cord, through the spermatic canal to the internal or deep abdominal ring. From the ring it curves around the outer side of the epigastric artery, crosses the external iliac vessel, and descends into the pelvis at the side of the bladder; it arches backward and downward to its base, crossing over the obliterated hypogastric artery and to the inner side of the ureter (Fig. 8, *d*). At the base of the bladder it lies between that viscus and the rectum, running along the inner border of the vesiculæ seminales. In this situation it becomes enlarged and sacculated, forming the ampulla (Fig. 8), and then, narrowing at the base of the prostate, unites with the duct of the vesicula seminalis to form the ejaculatory duct (Fig. 9). The vas deferens has dense walls, is about two feet long, cylindrical in form, about a line and a quarter in diameter, and its lumen is extremely small, measuring about one-half a

line. Its structure shows three coats: 1. An external or cellular coat; 2. A muscular coat, consisting of two layers of smooth muscular fibre; an outer, longitudinal, and an inner, circular. 3. An internal or mucous coat, which is pale, and arranged in longitudinal folds.

Vesiculæ Seminales.—The seminal vesicles (Figs. 8 and 9) are two convoluted membranous pouches sit-

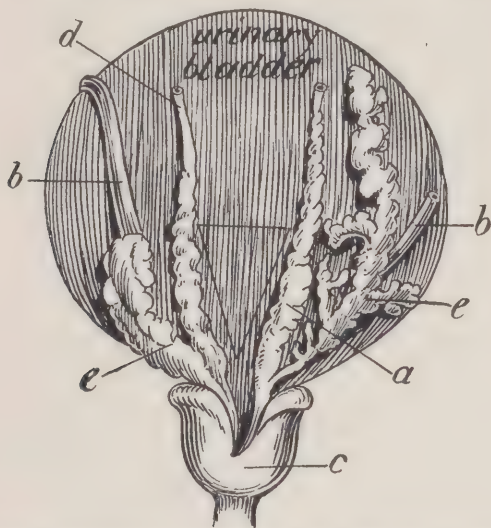


FIG. 8.—BASE OF THE BLADDER, WITH THE VASA DEFERENTIA AND VESICULÆ SEMINALES.

a, Ampulla; *b*, ureter; *e*, vesiculæ seminales; *d*, vas deferens; *c*, prostate gland.

uated between the base of the bladder and the rectum; they serve as reservoirs for the semen and secrete a fluid to be added to the secretion of the testicles. When distended, they form two long sacculated bodies, somewhat flattened on the side, the broad end being directed backward and the narrow end forward toward the

prostate, next the bladder, to which they are firmly attached. Each sac is somewhat pyramidal in form. They measure about two and one-half inches in length, about five lines in width, and two or three lines in thickness. They vary, however, in size, not only in different individuals, but also in the same individual on the two sides. Their upper surface is in contact with the base of the bladder, and extends from near the termination of the ureters to the base of the prostate gland. Their surface rests upon the rectum, from which they are separated by the recto-vesical fascia. Their posterior extremities diverge from each other upon the walls of the bladder. Their anterior extremities are pointed and converge toward the base of the prostate gland, where they join to form the ejaculatory duct (Fig. 9). A considerable amount of smooth muscular tissue is found covering the posterior surface and extending transversely between the two vesicles; there are also longitudinal fibres traceable over the vesicles from those of the bladder, and these serve as compressors, by the action of which their contents may be discharged.

Each vesicula consists of a single tube (Fig. 8, *e*), coiled upon itself, and gives off several irregular blind diverticula; the separate coils, as well as the diverticula, being bound together by fibrous tissue. When uncoiled, this tube is about the diameter of a quill, and varies in length from four to six inches; it terminates posteriorly in a cul-de-sac. The ejaculatory ducts, two in number (Fig. 9), one on each side, are formed by the junction of the ducts of the vesiculæ seminales with the vasa deferentia. Each duct is about three-quarters of an inch in length; it commences at the base of the prostate,

and runs forward and downward between the middle and lateral lobes, and along the side of the sinus pocularis, to terminate by a separate, slit-like orifice close to or

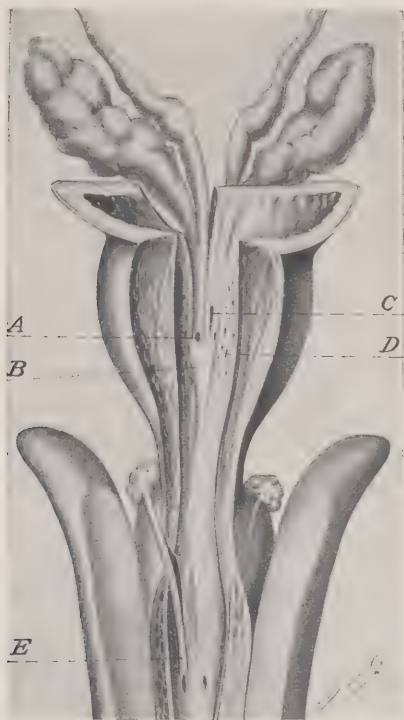


FIG. 9.—SHOWING THE STRUCTURES IN THE FLOOR OF THE PROSTATIC URETHRA. A, Orifice of the ejaculatory ducts; B, verumontanum; C, the utricle; D, prostatic ducts; E, duct of Cowper's gland. (Campbell.)

just within the margins of the sinus. The ducts diminish in size and converge toward their termination.

Structure of the Vesiculæ Seminales.—The vesiculæ seminales are composed of three coats: an external or

fibro-cellular coat; a middle or muscular coat; and an internal or mucous coat. The ejaculatory ducts have essentially the same structure as the vesiculæ seminales, except that their coats are very much thinner. The mucous coat of the vesiculæ seminales secretes and adds to the seminal fluid the whitish-colored mucus so characteristic of the semen. "The seminal vesicles are accessible to the rectal touch; hence by this route massage or milking of the ducts is performed" (Campbell).

The Prostate Gland.—The prostate gland (Figs. 8, 9, and 10) is situated at the neck of the bladder, and is pierced by the urethra and the ejaculatory ducts. It is somewhat chestnut-shaped and measures an inch and a

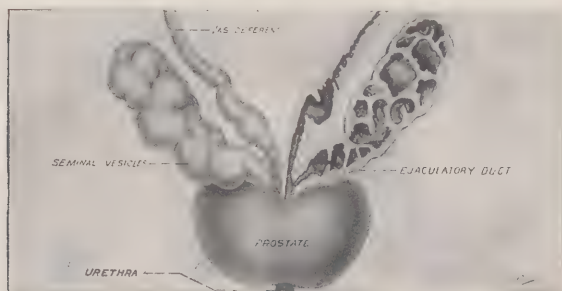


FIG. 10.—THE SEMINAL VESICLES AND DUCTS. (Campbell.)

half in breadth, an inch and a quarter in length, and half an inch in thickness. Its weight is about five drachms.

Structure.—The prostate is made up of compound tubular glands embedded in an abundance of muscular fibres and connective tissue. The glands are lined by columnar epithelium, with smaller cells lying between them and the basement-membrane. The numerous

follicular glands are drained by elongated canals, which join to form from twelve to twenty small excretory ducts, which open into the floor of the prostatic portion of the urethra.

The muscular tissue of the prostate forms the chief part of the stroma of the gland, and constitutes a continuous layer inside the fibrous sheath, as well as a layer surrounding the urethra and blending with the sphincter of the bladder.

Cowper's glands (Fig. 9) are two small, round lobulated bodies of a yellow color, about the size of a pea. They are situated close above the bulb, and are enclosed by the transverse muscular fibres of the compressor urethræ. They have each a single excretory duct, are lined throughout with cylindrical epithelium, and secrete a mucoid fluid, which is ejaculated with the semen. It is probable that this secretion is produced only during sexual excitement, and excreted as above mentioned.

The Penis.—The penis is the male organ of copulation. It consists of a root, body, and an extremity or the glans penis. The penis is composed of erectile tissue enclosed in three cylindrical fibrous compartments. The two corpora cavernosa are placed side by side along the upper part of the organ; the third, or corpus spongiosum, encloses the urethra and is placed below. The urethra throughout its entire length is beset with mucous glands, the secretion of which is mixed with the ejaculated semen.

CHAPTER III.

THE FEMALE GENERATIVE ORGANS.

THE human female generative organs consist of two ovaries, two Fallopian tubes, the uterus, and the vagina. The function of the ovaries is the maturation and the discharge of the ova. The Fallopian tubes, one of which is connected with each ovary, serve the purpose of selective fertilization of the ova while conducting them from the ovary to the uterus. The uterus receives and retains the fertilized ovum until the embryo becomes viable and fitted to maintain its existence independent of the placental connection with the mother. The vagina with its appendages receives the male organ in the act of copulation and subsequently discharges the foetus.

The Ovaries.—The ovaries (Figs. 11, *b*, 15) are two in number and are analogous to the testes in the male. They are oval-shaped bodies, situated one on each side of the uterus, in the posterior layer of the broad ligament behind and below the Fallopian tubes. Each ovary is connected by its anterior straight margin with the broad ligament; by its lower extremity with the uterus by a proper ligament (Fig. 11, *l*); and by its upper end with the fimbriated extremity of the Fallopian tube by the ovarian fimbria (Fig. 11, *e*). Its mesial and lateral surfaces and posterior convex border are free. The ovaries are of a grayish-pink color, and present either a smooth or a puckered, uneven surface. They are each about

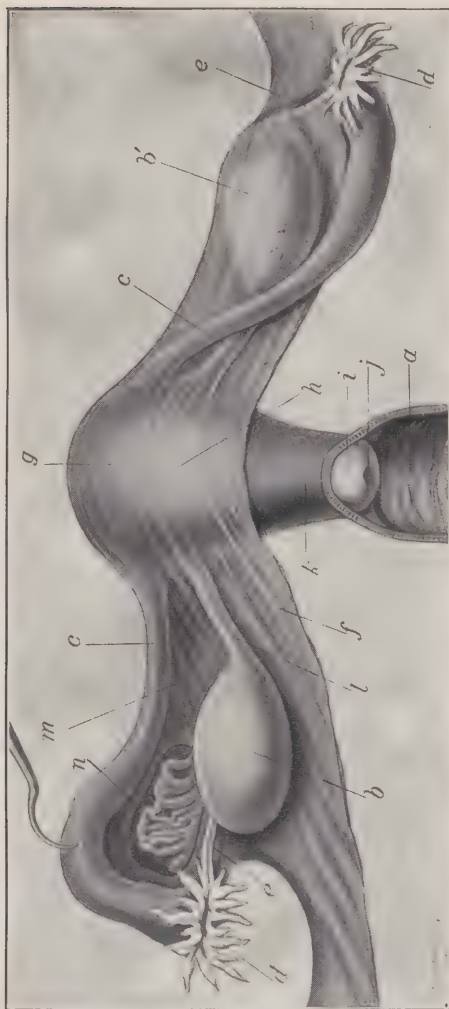


FIG. 11.—POSTERIOR VIEW OF THE UTERUS AND APPENDAGES.

a, Interior of vagina; *b*, the naked ovary; *b'*, ovary in its bursa (formed by the broad ligament); *c*, Fallopian tube; *d*, fimbriae of the Fallopian tube and its opening; *e*, the fimbria connected with the outer end of the ovary; *f*, broad ligament; *g*, fundus; *h*, body; *i*, vaginal part; *j*, mouth; *k*, neck; *l*, ligament of the ovary; *m*, mesosalpinx; *n*, epoöphoron.

an inch and a half in length, three-quarters of an inch in width, and about a third of an inch in thickness, and weigh from one to two drachms. The ovary possesses two extremities: (1) An outer, superior, or tubal extremity. (2) An inner, inferior, or uterine extremity. The ovary has two surfaces, an inner surface, which is also upper; an outer surface, which is also lower. The posterior or free border is markedly convex. The anterior border is almost straight and is narrow. The anterior border is not free, but is joined to the posterior layer of the broad ligament by a peritoneal fold known as the mesovarium. There is a groove in the anterior border called the hilum, through which vessels and nerves pass to the ovary and emerge from it. The posterior surface of the broad ligament covers the outer or lower surface of the ovary, while the mesosalpinx folds backward and inward over the inner or upper surface of the ovary (Fig. 11). The Fallopian tube passes around the posterior or free border and with the mesosalpinx covers its entire medial surface. Thus we see the posterior surface of the broad ligament in contact with both surfaces of the ovary forming the ovarian bursa, which is held in position by gravity and the pressure of the small intestine against the mesosalpinx and Fallopian tube covering the medial face of the ovary (Fig. 11, *b'*). Situated between the broad ligament and the mesosalpinx, according to Waldeyer, the ovary lies on the lateral pelvic wall and vertically when the woman takes the erect posture. Its tubal extremity is near the external iliac vein; its uterine end is directed downward. Its convex margin looks downward and backward toward the pelvic cavity and rectum, while its straight margin

or hilum lies laterally on the pelvic wall. Waldeyer also finds that it lies in a distinct but shallow groove limited above by the hypogastric artery and below by the uterus, in such a manner that the uterus lies along the convex margin of the ovary, and the hypogastric artery passes near the hilum or straight margin. In this connection it may be said that we can understand how gravitation may become a factor in sex production. If the woman knew which ovary had matured the ovum, a fact to be determined by pain or tenderness over the ovary during or immediately after menstruation, and should lie on that side after insemination, this position might hasten the ovum by gravitation to the fimbriated extremity (Fig. 11, *d*) of the Fallopian tube, and thus augment very materially the production of a male by hastening the ovum to the spermatozoön in the Fallopian tube before the latter becomes aged, small, and female-producing. Some authors speak of the ovum as falling on its extrusion from the Graafian follicle, when in fact there is never a moment in the normal condition when there is a cavity at any point on the surfaces or borders of the ovary, or in the peritoneal sac, until the surgeon or anatomist opens the abdomen, at which moment the peritoneal cavity is produced. For the reason stated, some part of the peritoneum is constantly in close relation with every part of the ovary. "Owing to the course pursued by the Fallopian tube round the ovary, the broad ligament forms a kind of curtain over the gland, and the ovary lies in a little pocket formed by the broad ligament, to which the name of bursa ovarii is applied" (Piersol) (Fig. 11, *b'*). The time consumed in the passage of the ovum from the Graafian follicle

after its rupture to the Fallopian tube is absolutely problematical.

When we understand the normal relation of the ovary and its situation in its bursa, we can very readily understand how in a certain number of cases there is a migration of the ova, which pass across the abdominal cavity and come down the opposite tube; this is called external migration. In the case of bicornate uterus a corpus luteum may be found in the one ovary and pregnancy in the other side of the uterus. "Leopold and others have experimented by removing in an animal a tube and the opposite ovary. Later, if the animal became pregnant the proof of external migration was positive. I have repeatedly demonstrated this external migration of the ovum by operation upon rabbits in the Loomis Laboratory. Older writers declared that there was internal migration causing tubal pregnancy in the opposite tube, the ovum having passed through the uterus. This statement cannot be denied, neither can it be proved; hence we see that external migration does take place, whereas the occurrence of internal, though possible, has not been proven" (Edgar).

The above experiments are proof positive that the woman, by lying on the side which matured the ovum, may hasten its progress to the fimbriated extremity of the Fallopian tube, where it is picked up and wafted to the uterus. If the woman is sure as to the ovary which matured the ovum and lies on that side for two to three hours after insemination the very best opportunity will have been given it to gravitate to and then be picked up by the fimbriated extremity of the tube. If the woman is not positive as to the ovary which matured the ovum,

she should choose the most comfortable side to lie on and remain on that side for four or five hours, just after insemination. If there is known to be a pathological condition in one ovary, then she should choose the opposite side to lie on; this will gravitate the ovum from the tube in which there would be reasons to apprehend a stenotic or other pathological change and which would retard or stop the progress of the ovum to the uterus. If the ovaries are in a normal condition it is always better to assist by gravity the ovum to the Fallopian tube of the ovary which matured it. The blood supply is always greater in the tube of the ovary which matured the ovum, this increased blood supply enlarges the lumen of the tube and allows the ovum to pass through more readily. Five or six hours should be ample time for external migration of the ovum.

Structure of the Ovary (Figs. 11, 12).—The ovary consists of a number of Graafian follicles embedded in the stroma or framework, and invested by a serous covering derived from the peritoneum.

Serous Covering (Fig. 12, *a*).—Though the investing membrane of the ovary is continuous with the peritoneum and originally derived from it, the epithelium of the ovarian serosa is of the short columnar variety, while that of the peritoneum is squamous.

Stroma.—The stroma is a peculiar soft tissue, abundantly supplied with blood-vessels, and consists for the most part of spindle-shaped cells, with a small amount of ordinary connective tissue. These cells have been regarded by some anatomists as non-striated muscle-cells, which they most resemble (His); by others as connective-tissue cells (Waldeyer, Henle, and Kölliker). On the

surface of the organ, this tissue is most condensed, and forms a layer composed of short connective-tissue fibres, with fusiform cells between them. This was formerly regarded as a distinct fibrous covering, and was termed the tunica albuginea, but is nothing more than a condensed layer of the stroma of the ovary. The stroma



FIG. 12.—SECTION OF THE OVARY OF THE CAT. λ^2 .

a, Germ-epithelium; *b*, remains of egg-tubes; *c*, small follicle; *d*, more advanced follicle; *e*, discus proligerus and ovum; *f*, second ovum in the same follicle (this occurs but rarely); *g*, outer tunic of the follicle; *h*, inner tunic; *i*, membrana granulosa; *k*, collapsed retrograded follicle; *l*, blood-vessel; *y*, involuted portion of the germ-epithelium of the surface; *z*, place of the transition from the peritoneal to germinal or ovarian epithelium.

also contains, near its attachment to the broad ligament, a large number of plain muscular fibres (Schafer). It is more than probable that these muscular fibres contract during orgasm, prevent the escape of blood from the ovary, and thus aid in rupturing the Graafian follicle at that moment, this being analogous to the ejection of

semen in the male. The stroma encloses vesicles of different sizes, the smallest being near the surface of the organ, the large ones placed more deeply in the stroma, although, as they increase in size, they extend toward the surface.

These vesicles are the Graafian follicles. Each Graafian follicle has a proper wall formed of a layer derived from the stroma, and a special inner layer containing large cells; both are highly vascular. Each follicle contains an ovum (Fig. 12, *f*, *e*) and epithelium. The fact that the largest and those most centrally located in the ovary are the follicles to reach maturity first, gives us a good reason to anticipate the maturity of the follicle at about the same time after each menstruation in the same individual in her normal condition. If the superficial follicles or those nearest the surface of the ovary were the ones which come earliest to maturity, then the time for maturity of the Graafian follicle would be problematical indeed.

If maturation of the ovum began upon rupture of the Graafian follicle, allowing thirty minutes to each division of the cell for the formation of the polar bodies, it would consume about an hour, and this should be ample time for the ovum to reach the Fallopian tube after its liberation from the follicle. Then the spermatozoa will have had time to reach the fimbriated extremity of the Fallopian tube after insemination. Maturation (formation of the polar bodies) having been completed, cell-division (cleavage) proceeds upon the entrance of the spermatozoon, without pausing a moment.

The Corpus Luteum.—After the Graafian follicle has ruptured and the ovum has been set free, the corpus

luteum is formed. The rupture may occur either on the surface of the ovary or within its stroma. The follicle may be prevented from migrating to the surface of the ovary by laceration of the tunica granulosa, superinduced by rupture of its proper wall (theca folliculi); by coming in contact with cicatricial tissue (from degenerating corpora lutea); or those located near the hilum, in developing, may come in contact with it. When the follicle ruptures within the ovary the ovum is most sure to be dislodged from its normal position in the discus proligerus, and as the follicular secretion is taken up by the circulation, after a time, the ovum shrivels, disintegrates, and is ultimately absorbed. When rupture of the follicle occurs on the surface of the ovary the ovum is normally extruded with the follicular secretion. Immediately after the rupture of a Graafian follicle the cavity is filled with a blood-tinged fluid, and in a short time the rupture in the wall through which the ovum escaped becomes closed. The cavity becomes filled with cells, separated into groups by trabeculae of connective tissue containing blood-vessels. These cells contain a considerable amount of yellow pigment known as lutein, this peculiar color having suggested its name corpus luteum.

In later stages there is a gradual increase in the quantity of connective tissue and a corresponding diminution of the lutein cells. It gradually loses its characteristic color and becomes converted into a whitish, fibrous, scar-like body—the corpus albicans—which may eventually almost completely disappear. The rapidity with which the various stages of retrogression ensue differs according to whether pregnancy occurs or not, and it is customary

to distinguish the corpora lutea which are associated with pregnancy as corpora lutea vera from those whose ova fail to be fertilized and which form corpora lutea spuria. In the latter the retrogression of the follicle is completed usually in about five or six weeks, while the corpora vera persist throughout the duration of the pregnancy and complete their retrogression after parturition.

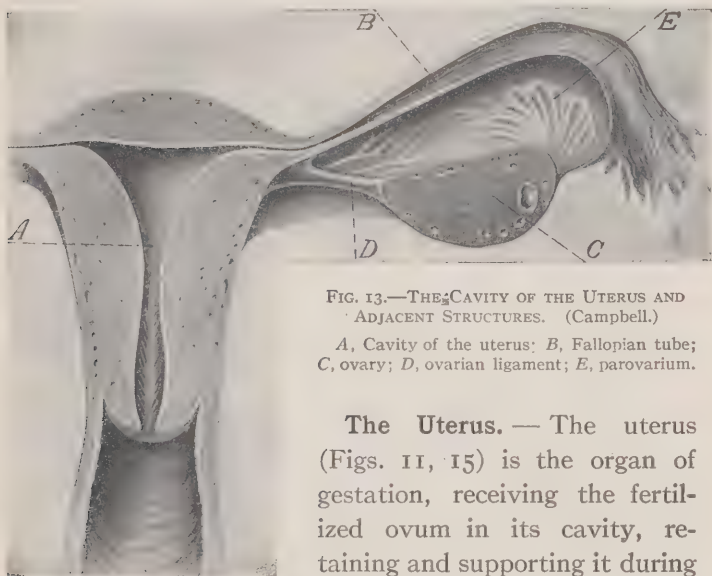


FIG. 13.—THE CAVITY OF THE UTERUS AND ADJACENT STRUCTURES. (Campbell.)

A, Cavity of the uterus; B, Fallopian tube; C, ovary; D, ovarian ligament; E, parovarium.

The Uterus. — The uterus (Figs. 11, 15) is the organ of gestation, receiving the fertilized ovum in its cavity, retaining and supporting it during the development of the foetus,

and becoming the principal agent in its expulsion at the time of parturition. In the virgin state it is pear-shaped, flattened from before backward, and situated in the cavity of the pelvis between the bladder and the rectum; it is retained in its position by the round and broad ligaments on each side, and projects into

the upper end of the vagina below. Its upper end, or base, is directed upward and forward; its lower end, or apex, downward and backward in the line of the axis of the inlet of the pelvis. It therefore forms an angle with the vagina, since the direction of the vagina corresponds to the axis of the cavity and outlet of the pelvis. The uterus measures about three inches in length, two in breadth at its upper part, and an inch in thickness, and it weighs from an ounce to an ounce and a half.

The fundus is the upper broad extremity of the organ: it is convex, covered by peritoneum, and placed on a line below the level of the brim of the pelvis.

The body gradually narrows from the fundus to the neck. Its anterior surface is flattened, covered by peritoneum in the upper three-fourths of its extent, and separated from the bladder by some convolutions of the small intestine; the lower fourth is connected to the bladder. Its posterior surface is convex, covered by peritoneum throughout, and separated from the rectum by some convolutions of the intestine. Its lateral margins are concave and give attachment to the Fallopian tube above, the round ligament below and in front of this, and the ligament of the ovary behind and between both of these structures.

The cervix is the lower rounded and constricted portion of the uterus; around its circumference is attached the upper end of the vagina, which extends upward a greater distance behind than in front.

At the vaginal extremity of the uterus is a transverse aperture, the os uteri, bounded by two lips, the anterior of which is thick, the posterior narrow and long.

The ligaments of the uterus are eight in number: two

anterior, two posterior, two lateral formed of peritoneum, and the round ligaments.

The two anterior ligaments are two similar folds which pass between the neck of the uterus and the posterior surface of the bladder.

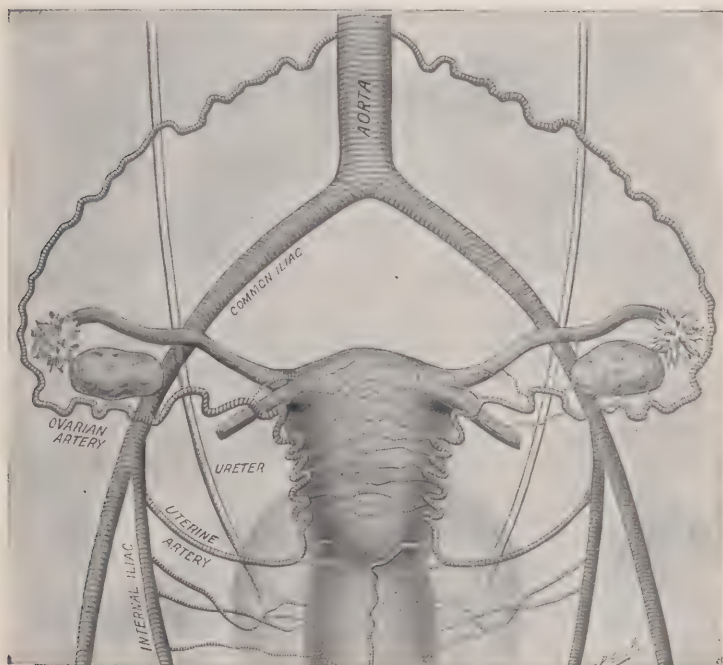


FIG. 14.—THE UTERO-OVARIAN VASCULAR CIRCULATION. (Campbell, after Robertson.)

Shadow outline of the bladder in front.

The two posterior ligaments pass between the side of the uterus and rectum.

The two lateral or broad ligaments pass from the side of the uterus to the lateral walls of the pelvis, forming a

septum across the pelvis which divides that cavity into two portions. In the anterior part are contained the bladder, the urethra, and vagina; in the posterior part, the rectum.

The cavity of the uterus (Fig. 13, *A*) is small in comparison with the size of the organ: that portion of the cavity which corresponds to the body is triangular, having its base directed upward toward the fundus, and is flattened from before backward, so that its walls are closely approximated. At each superior angle is a funnel-shaped cavity which constitutes the remains of the division of the body of the uterus into two cornua, and at the bottom of each cavity is the minute orifice of the Fallopian tube. At the inferior angle of the uterine cavity is a small constricted opening, the internal orifice, which leads into the cavity of the cervix. The cavity of the cervix is somewhat fusiform, flattened from before backward, broader at the middle than at either extremity, and communicates below with the vagina. Each wall of the canal presents a longitudinal column, from which proceed a number of small oblique columns, giving the appearance of branches from the stem of a tree.

Structure.—The uterus is composed of three coats—an external serous coat, a middle or muscular layer, and an internal mucous coat.

The serous coat is derived from the peritoneum; it invests the fundus and the whole of the posterior surface of the body of the uterus, but only the upper three-fourths of its anterior surface.

The muscular coat forms the chief bulk of the substance of the uterus. In the unimpregnated state it is

dense, firm, of a grayish color, and cuts almost like cartilage. It is thick opposite the middle of the body and fundus, and thin at the orifices of the Fallopian

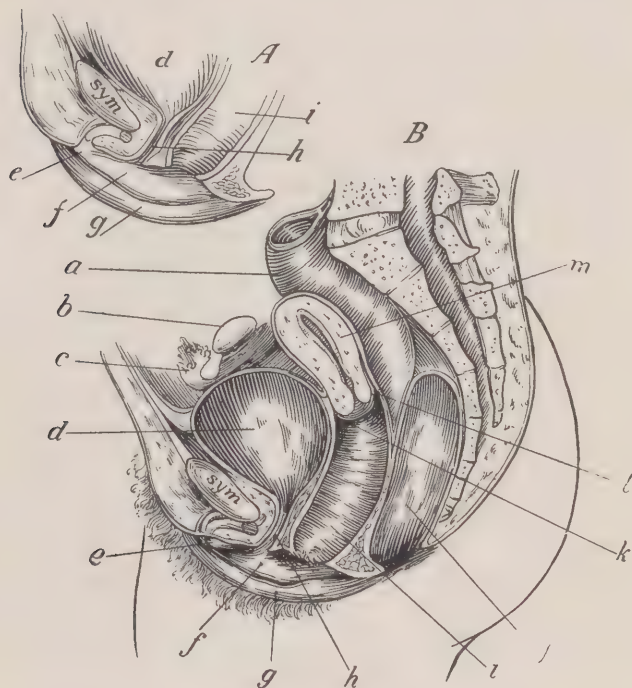


FIG. 15.

A, Small Section of Female Generative Organs, Showing the Changed Condition in the very Corpulent Woman. Note the increased size of the labium majus and minus, also how the glans clitoridis is protected.

B, Section of Female Pelvis, Showing Position of Viscera. *a*, Rectum; *b*, ovary; *c*, fimbriated extremity of the Fallopian tube; *d*, bladder; *e*, glans clitoridis; *f*, labium minus; *g*, labium majus; *h*, urethra; *i*, vagina; *j*, interior of rectum; *k*, anterior; *l*, posterior lips of os uteri; *m*, uterus.

tubes. It consists of bundles of unstriped muscular fibres, disposed in layers, intermixed with areolar tissue,

blood-vessels, lymphatic vessels, and nerves. In the impregnated state the muscular tissue becomes more prominently developed, and is disposed in three layers—external, middle, and internal.

The mucous membrane is thin, smooth, and closely adherent to the subjacent tissue. It is continuous, through the fimbriated extremity of the Fallopian tubes, with the peritoneum, and through the os uteri with the mucous membrane lining the vagina.

In the body of the uterus it is smooth, soft, of a reddish color, lined by columnar ciliated epithelium, and presents, when viewed with a lens, the orifices of numerous tubular follicles arranged perpendicularly to the surface. They are of small size in the unimpregnated uterus, but shortly after impregnation they become enlarged, elongated, presenting a contorted or waved appearance toward their closed extremities, which occasionally dilate into two or three sacculated pouches. The circular orifices of these glands may be seen on the inner surface of the mucous membrane, many of which during the early period of pregnancy are surrounded by a whitish ring formed of epithelium which lines the follicles. In the impregnated uterus the epithelium loses its ciliated character.

In the cervix (Fig. II, *k*) the mucous membrane between the rugæ and around the os uteri is provided with numerous mucous follicles and glands. The small, transparent, vesicular elevations so often found within the os and cervix uteri are due to closure of the mouths of these follicles and their distention with their proper secretion. They are called the ovula of Naboth. The mucous membrane covering the lower half of the cervix

presents numerous papillæ, and the epithelium is stratified.

Vessels and Nerves.—The arteries (Fig. 14) of the uterus are the uterine, from the internal iliac, and the ovarian, from the aorta. The nerves are derived from the inferior hypogastric and ovarian plexuses and from the third and fourth sacral nerves.

Appendages of the Uterus.—The appendages of the uterus are the Fallopian tubes, the ovaries and their ligaments, and the round ligaments.

The Fallopian Tubes.—The utero-peritoneal canal (Figs. 11, 13) was discovered by Fallopio Gabriello, an Italian anatomist, born in 1523 at Modena, and still bears his name. Recent observers, more especially Leukart, Thiersch, and Kölliker, describe the embryological formation of these organs.

In the walls of the Wolffian body (Figs. 1, 2), situated near the kidneys on each side, in the female embryo, a narrow tube develops, which runs downward parallel with the excretory duct of this body, and ends below in the two horns of the uterus, while the distal extremity performs "a movement of rotation from before backward and from above downward; the whole, together with the ligaments of the ovaries and the round ligaments, being enveloped in double folds of the peritoneum, which enlarge with the growth of the parts themselves, and constitute finally the broad ligaments of the uterus." * The two tubes approach each other below, and come together upon the median line, where they undergo fusion, forming the lower portion of the uterus and the

* "Treatise on Human Physiology," by J. C. Dalton.

entire vagina down to the hymen. The fundal arch is now developed, according to Kölliker, who experimented on cattle, and who believes that this development occurs from the centre. All this occurs very early in embryonic life; according to Dohrn, it is completed by the second month. "During these changes in the adjacent organs, the two lateral halves of the uterus fuse with each other on the median line, and become covered with muscular fibres. In quadrupeds, the uterus remains divided for the most part into two long conical tubes or cornua. In the human species, the fusion between the lateral halves of the organ is nearly complete; so that the uterus presents externally a rounded, flattened, and somewhat triangular figure, with the ligaments of the ovary and the round ligaments passing off from its upper corners. Internally, its cavity still presents a strongly marked triangular form, the vestige of its original division. Occasionally the human uterus remains divided internally by a vertical septum, running from the middle of its fundus toward the os internum. It may even present a partial external division, corresponding to the situation of the septum, and producing the malformation known as uterus bicornis or double uterus.

"The Fallopian tubes or oviducts are two in number, one on each side, situated in the upper margin of the broad ligament, extending from each superior angle of the uterus to the sides of the pelvis. Each tube is about four inches and a quarter in length, and is placed in a fold of peritoneum, which is part of the broad ligament and is called the mesosalpinx. Each tube is described as consisting of three portions: (1) the isthmus, or inner constricted third; (2) the ampulla, or outer

dilated portion, which curves over the ovary; and (3) the infundibulum, the funnel-like expansion of the tube, at the bottom of which is the abdominal orifice or pavilion. The abdominal orifice has a small diameter (2 mm. when relaxed to its full extent). The margin of the infundibulum is rendered irregular by the presence of numerous small processes (Fig. 11, *d*), the fimbriæ. The surfaces of the fimbriæ looking into the cavity of the infundibulum are covered with mucous membrane continuous with the tubal mucous membrane. The outer surfaces are covered with peritoneum. One of the fimbriæ (Fig. 11, *e*) is attached to the ovary and is called the ovarian fimbria. The uterine portion of the tube is in the uterine wall. The opening in the uterus is even smaller than the abdominal opening, and will admit only a small bristle. The general direction of the Fallopian tube is outward, backward, and downward. In connection with the fimbriæ of the Fallopian tube, or with the broad ligament close to them, there is frequently one or more small vesicles floating on a long stalk of peritoneum. They are representative of small portions of the upper extremity of the Wolffian duct" (Gray).

Course Pursued by the Fallopian Tube.—The tube on each side begins at the upper and outer angle of the uterus and passes outward in a horizontal direction toward the uterine extremity of the ovary. It then bends almost at a right angle and ascends close to the pelvic wall and in front of the anterior margin to the tubal extremity of the ovary. At this point it turns sharply downward and a little backward, and the inner surface of the infundibulum comes to lie upon the free

margin and the posterior portion of the inner surface of the ovary (Fig. 11, *b*).

Structure.—The Fallopian tube consists of three coats—serous, muscular, and mucous.

The external or serous coat is peritoneal. Beneath this lies the tunica adventitia, composed of lax connective tissue.

The middle or muscular coat consists of an external longitudinal layer, and an internal circular layer of plain muscular fibres continuous with those of the uterus.

The internal or mucous coat is continuous with the mucous lining of the uterus and, at the free extremity of the tube, with the peritoneum. It is thrown into longitudinal folds, which, in the outer, large part of the tube or ampulla, are much more extensive than in the narrow canal of the isthmus. The lining epithelium is columnar and ciliated. This form of epithelium is also found on the inner surface of the fimbriæ, while on the outer or serous surface of the processes the epithelium gradually merges into the endothelium of the peritoneum.

The organ of Rosenmüller is placed in the mesosalpinx, between the ovary and tube (Fig. 11, *n*). It consists of a number of epithelium-lined closed tubes. This structure can be readily seen if the mesosalpinx is stretched and held in front of the light. One of these tubes runs parallel to the Fallopian tube and is called Gärtner's duct. A number of tubes ascend from near the ovary and each empties into Gärtner's duct at a right angle. Gärtner's duct is a portion of the Wolffian duct, which has perished and is represented in the male by the canal of the epididymis. The tubules which join the duct are

derived from the mesonephros and represent the vasa efferentia and coni vasculosi of the testis, and probably also the ductuli aberrantes of the canal of the epididymis. The paroöphoron is within the mesosalpinx, but is nearer to the uterus than is the organ of Rosenmüller. It consists of several small tubules, which can be seen in an adult only by the aid of a pocket lens. They are visible to the naked eye in a child at birth. It represents the organ of Giralaldès in the male and is derived from the mesonephros.

The chief artery of the Fallopian tube is the tubal branch of the uterine artery. It also receives branches from the ovarian. Some of the tubal veins empty into the uterine veins, some into the ovarian veins. The lymphatics coming from the tube unite with the trunks coming from the uterus and ovary and terminate in the juxta-aortic gland. The nerves come from the same plexuses that send branches to the uterus and ovary.

Function.—The function of the Fallopian tubes varies in different animals. The mucous membrane of the Fallopian tubes in the lower animals is usually adapted for supplying certain secretions during the passage of the egg, which secretions complete its formation. In the frog, the Fallopian tube commences at the upper part of the abdomen, by a rather wide orifice, which communicates with the peritoneal cavity. It then contracts abruptly to a narrow tube, which is lengthened by folding upon itself in numerous convolutions, until it opens, near its fellow of the opposite side, into that part of the intestinal canal known as the cloaca. This is also the general character of the oviducts in nearly all reptiles and birds; the birds have but one oviduct;

the right oviduct with the corresponding ovary atrophies in early embryonic life.

“ In the frog, after the ripening of the eggs and their discharge from the ovarian follicles, they receive an additional investment in the oviducts. On leaving the ovary, they consist only of the dark-colored vitellus, enclosed in its vitelline membrane. Their passage through the oviduct is effected by the peristaltic contraction of its walls, aided by the abdominal muscles. During this passage, an albuminous substance, secreted by the oviduct, is deposited round each egg in successive layers, forming a thick envelope. When the eggs are discharged, they absorb moisture from the water in which they are deposited, and swell into a transparent mass, in which the eggs are embedded. By its subsequent liquefaction and absorption, it supplies material for the nourishment of the embryo. The frog's eggs are fertilized after they pass through the Fallopian tube. In birds and scaly reptiles, the Fallopian tube performs a more important function; the spermatozoa pass through its lumen to the ovary, where fertilization of the ovum takes place before its extrusion from the Graafian follicle; and several membranes are added to the vitellus during its passage through the Fallopian tube.”

The ovum of the bird is fertilized while it is yet in the ovary. The spermatozoa have very little resistance to overcome in penetrating the covering membranes of the egg, for they are distended to their fullest capacity by the ovum itself, until they are so thin and delicate as to be very readily pierced by the spermatozoa. In Dalton's beautiful description of the female generative organs of the bird he says: “ In scaly reptiles and birds,

the oviducts perform a more important function. In the common fowl, the ovary consists of follicles of various size, loosely united by connective tissue, and containing eggs in different stages of development. As the egg which is approaching maturity enlarges, it distends its follicle, and projects from the general surface of the ovary; so that it hangs at last into the peritoneal cavity, retained only by the attenuated wall of the follicle, and a slender pedicle containing its blood-vessels. A rupture of the follicle then occurs at its most prominent part, and the egg is discharged from the lacerated opening. As the egg leaves the ovary, it consists of a large, globular, orange-colored vitellus, or 'yolk,' enclosed in a thin transparent vitelline membrane. Immediately beneath the vitelline membrane, on the surface of the vitellus, is a round white spot, consisting of a layer of minute granules, termed the 'cicatricula,' in which the germinative vesicle was previously embedded. At this time the germinative vesicle has usually disappeared; but the cicatricula is still an important part of the vitellus, and marks the spot from which the embryo begins its development. From the surface of the ovary, the yolk projects into the orifice of the oviduct; and when discharged from its follicle, it is embraced by the extended upper extremity of this tube, and commences its downward passage.

"In the fowl, the muscular coat of the oviduct is highly developed, and its peristaltic contractions urge the egg from above downward, somewhat as the œsophagus or the intestine transports the food in a similar direction. While passing through the first 5 or 6 centimetres of the oviduct, where the mucous membrane is smooth

and transparent, the yolk absorbs a certain quantity of fluid, becoming consequently softer and more flexible. It then passes into a second division of the canal, in which the mucous membrane is thicker and more globular in texture, and arranged in longitudinal folds. This portion extends over about 22 centimetres, or more than one-half the length of the oviduct. In its upper part, it secretes a viscid material, which consolidates into a gelatinous deposit around the yolk, thus forming a second envelope, outside the vitelline membrane. The peristaltic movements of the oviduct are such as to give a rotary, as well as a progressive motion to the egg; and by this means the two extremities of the gelatinous envelope become twisted in opposite directions, forming rope-like extensions at the two poles of the egg. They are termed the 'chalazæ,' or suspensory cords, and the membrane with which they are connected is the 'chala-ziferous membrane.'

"Throughout the remainder of this part of the oviduct, an albuminous substance is deposited in successive layers around the yolk, including the chala-ziferous membrane and chalazæ. This substance, the so-called albumen, or 'white of egg,' is gelatinous in consistency, nearly transparent, and of a faint amber color. It is deposited in greater abundance in front of the egg than behind it, and thus forms a conical projection anteriorly, while behind, its outline is parallel with the spherical surface of the yolk. In this way, the egg acquires, when covered with its albumen, an ovoid form, of which one end is round, the other pointed; the pointed extremity being directed downward, as the egg descends through the oviduct.

“ In the third division of the oviduct, which is about 9 centimetres in length, the longitudinal folds of the mucous membrane are narrower and more closely packed than in the preceding portion. Its secretion condenses into a fibrous covering, composed of three layers, closely embracing the surface of the albuminous mass, and forming a tough, flexible, semi-opaque envelope for the whole. These layers are known as the external, middle, and internal fibrous membranes.

“ Finally the egg passes into the fourth division of the oviduct, which is wider than the rest of the canal, but only a little over 5 centimetres in length. Its mucous membrane, which is covered with abundant leaf-like villousities, exudes a fluid rich in calcareous salts. The external fibrous layer is permeated by this secretion; and afterward, owing to the reabsorption of fluid, the calcareous matter is deposited in its network. The deposit goes on, growing thicker and more condensed, until the membrane is converted into a white, opaque, brittle, calcareous shell. The egg is then forced through a narrow portion of the oviduct, and, gradually dilating the passages by its conical extremity, is discharged from the external orifice.”

In mammals the Fallopian tube is the ideal place for select fertilization, and it may take place at any point in the tube, the nearer the fimbriated extremity the greater the endurance and the better the selection of the spermatozoön. If rupture of the Graafian follicle took place during insemination, the spermatozoa would be able to meet the ovum near the fimbriated extremity of the tube, when fertilization would take place and cell division would begin immediately. The passage of the

ovum through the Fallopian tube should not consume more than three hours. It is hard to understand how so many have arrived at the estimation of eight days as the time required for the ovum to pass through the Fallopian tube, when we know how rapidly all kinds of foreign matter are eliminated from the lung by the same kind of membrane and over twice the distance in less than half the time above given (three hours). Fertilization of the ovum in the human ovary may take place only when the ovum remains in the Graafian follicle after its rupture, the spermatozoön gaining entrance through the rent made by the rupture. In the human species it is a matter of impossibility for the spermatozoön with its large club-shaped acrosomeless head to penetrate the three tunics (ovarian envelope, membrana granulosa, and discus proligerus) and fertilize the ovum. Ovarian fertilization is most undesirable, for it causes the inevitable death of the foetus, and great danger to the life of the mother. Fertilization may take place in the peritoneal cavity and yet the ovum find its way to the fimbriated extremity of the Fallopian tube where it would be picked up and wafted through the tube to the uterus where pregnancy proceeds normally. Or fertilization may take place in the uterine cavity; but this is undesirable for the reason that fertilization of the ovum is limited only to the power necessary for the spermatozoön to enter the uterus and penetrate the vitelline membrane of the ovum.

The movements of the cilia could not be a great barrier to the progress of the spermatozoa, but the current set up in the mucous secretion is to be overcome by them without ceasing. The constant struggle necessary to

maintain a position in any part of the Fallopian tubes soon reduces the largest and best male-producing spermatozoa to female-producing by consuming the nutriment stored up in the nucleus. The old, inactive, and decrepit spermatozoa are wafted back into the uterine cavity and from there to the vagina.

In the above-described mechanism, we see nature selecting the most active specimen of the spermatozoa for propagation. In the production of a male, the most active spermatozoön, be it large or small, of little or great endurance, will stand the same chance to fertilize the ovum as the large and those more capable of a greater endurance. This condition of male-production gives rise to the greater variation in size and endurance of the male. Where there is a delay of the ovum to arrive, and this is often the case, the male-producing spermatozoön becomes female-producing. Here we see the best tested spermatozoa producing the female, giving to her greater uniformity in size and endurance. This would indicate that the female uniformly should have just a little greater endurance than the male, and the truth of this law is shown in my statistics as given in which the mortality is thirteen per cent greater in the male in the aggregate mortality of five hundred and seventy-seven children under five years of age. Mr. Charles Darwin mentions this fact in the "Descent of Man," Part II., Sexual Selection, Chapter VIII., in which he says: "It is a well ascertained fact that with man the number of males dying before or during birth and during the first few years of infancy is considerably larger than that of females. So it almost certainly is with male lambs, and probably with some other animals."

In this case an author has made this statement from facts deduced from a record of millions of children and not hundreds as I have given. My statistics only go to confirm this law for which Mr. Darwin was unable to give a tenable answer or cause.

"The International Clinics," Vol. II., 21st Series: In Montgomery's article on the cellular basis of the determination of sex, where this law is noted, we find the following: "And it may also be noted that the numerical ratio of the sexes is not always 1 : 1 as generally assumed, even where there are separated males and females in the same generation. Thus in 10,864,950 human births there were found 103.6 males to 100 females (Pike, 1907), and for 'still-born infants, fully formed but not alive,' Quetelet found 133.5 males to 100 females (Morgan, 1907)."

In the quadrupeds and man, there is a further modification of the oviducts. They serve two purposes: they furnish an ideal field for fertilization of the ovum, and convey the minute, motionless ovum from the reproductive glands to the uterus for development. It is claimed by some that the ova receive a small quantity of albuminous secretion during their passage through the lumen of the oviducts to the uterus,—*this is true only after fertilization takes place and cell division has begun*. The ovum is immersed for many days before its extrusion from the Graafian follicle in an albuminous secretion, which is wafted along with it into the uterine cavity. When the normal ovum leaves the Graafian follicle, it has absorbed all it is capable of absorbing until cell division begins. There is nothing lost on account of its passage through the Fallopian tube. There is no

motion on its part to consume anything, which is true of all ova of both the vertebrate and the invertebrate animals. The lumen of the oviduct and the cavity of the uterus of all mammals are lined with ciliated epithelium, the motion of which produces a current in the mucous secretion from the ovary to the uterus, and from the uterus to the vagina. The vigorous lashing, whip-like movements of the cilia are so rapid and the rythm is so frequent (twelve or more times a second), that it is hard to follow the motion with the eye. This vigorous motion of the cilia produces such a rapid current in the fluid contents of the tube, that the deformed, the weak, and the decrepit spermatozoa are wafted back into the uterus and from there into the vagina, as soon as they are unfit for fertilization. The minute orifice of the Fallopian tube at the uterine extremity serves to increase the current of the mucous secretion through this part of the tube, and this rapidity renders it more difficult for the spermatozoa to enter the Fallopian tubes in the contest for fertilization; and, after they enter the tubes, they are continually put to the test by the constant current set up in the mucous secretion by the ceaseless motion of the cilia. In this we see nature's most beautiful mechanism for selecting the fittest of these microscopic living organisms (called spermatozoa) for propagation. It is this mechanism that selects the most active, and goes far to secure for fertilization the best, strongest, and most vigorous spermatozoa present.

In studying a microscopic field of a specimen of semen, recently removed from the vesiculæ seminales, we see one or two intensely active spermatozoa, while there are a hundred or more moving normally. On closer exam-

ination of these active spermatozoa their nucleus is found to be very small, and they would ordinarily be classed as female-producing spermatozoa. When such a spermatozoön reaches the ovum, it will dash through the vitelline membrane into the cytoplasm, entering with both body and tail, and thus produce a male. This result is due to the intense rapidity of its movements. The male produced from such an ultra-active spermatozoön is defective, weak, and delicate, and this fact may account for the great mortality among male children, which is one hundred and thirty-three male to one hundred female under five years of age. The sooner fertilization takes place after the ovum enters the Fallopian tubes, the better, and the greater is the chance for a strong active spermatozoön. It is only the strongest and most active spermatozoa that make their way to the ovarian extremity of the Fallopian tubes. Fertilization of the ovum in the uterus is most undesirable, for the reason that the spermatozoa there found may have been too weak to undergo the severe test of passing through the Fallopian tubes. Should fertilization take place in the uterine cavity, the ovum is liable to be wafted out into the vagina before it can attach itself, or toward the lower part of the uterus, where it produces a condition known as placenta prævia. It is necessary for cell division of the ovum to be in rapid progress, that the more fluid constituents of the mucus be taken up, and that viscid constituents which serve to fix the fertilized ovum be left without. As soon as the mucus immediately surrounding the ovum becomes viscid through absorption from within the ovum, the cilia adhere to it, and further migration of the ovum ceases.

It is not necessary for the ovum to be wafted into a depression in order to become fixed; it is probable that it becomes attached to an eminence in the wall of the uterus more often than to a depression.

The conveyance of the ovule through the Fallopian tube is accomplished by the movement of the cilia, which takes up the fluid of the ruptured Graafian follicle in which the ovule is immersed, and wafts them both into the uterine cavity. The time consumed in the passage of the ovule through the Fallopian tube has been variously estimated: Barnes gives eight days and longer; Parvin says, "some time intervenes between coition and conception, between insemination and impregnation; this interval possibly is some hours, and it may be, as illustrated by the fecundation of the hen's egg twelve days before it is laid, several days." Inasmuch as fertilization of the bird's egg takes place before it leaves the Graafian follicle, the comparison of it to that of the human female is without weight, because the human ovule is never fertilized until after its extrusion from the Graafian follicle. In the human species six hours should be considered a prolonged time, while three hours are scarcely ever consumed in the conveyance of the ovule through the Fallopian tube. It is probable that this is accomplished in less than two hours in the majority of cases. This may be determined with reasonable accuracy by comparing the movement of foreign matter wafted through the bronchial tubes, with that obtained in the Fallopian tubes. Both are lined with ciliated epithelium, but the bronchial tubes are twice the length of the oviducts. Thus the oviducts are favored in both power and rapidity for moving foreign substances

through them. When a foreign substance is wafted through the oviducts, it is encompassed by the cilia, whose movements are ceaseless until it is eliminated. When the cilia fail to move it, the peristaltic action of the duct is set up, which augments the onward movement. The bronchial tubes are hollow cylinders, lined with ciliated epithelium. A foreign substance in the lung is immersed in mucus and wafted along the sides of the bronchial tubes with the disadvantage of the drying effect of the air-current through the tubes. Still we would consider six hours a very long time for a foreign substance to be wafted from the remotest part of the lung to the larynx.

Diseases of the Fallopian Tubes.—Reproduction of all mammals is dependent upon the maintenance of the lumen in the Fallopian tubes, and their ability to take up and convey the ovula from the ovary to the uterine cavity. The human is the only species of the mammalian group of animals subject to disease of the Fallopian tubes, caused by gonorrhœal or septic infection, the latter occurring after labor, or following the introduction of septic instruments into the uterus. A purulent salpingitis may run a chronic course of a catarrhal type, simply thickening the walls of the tubes and causing the formation of adhesions about them, the tubes remaining patent and draining into the uterus, and a purulent endometritis being associated with the tubal disease. More commonly, the connection with the uterus is obstructed, although the uterine end is never completely closed, and the tube is distended by the accumulating purulent secretion. The open end of the tube at the fimbriated extremity is closed very early by adhesions,

and the result is a pus sac formed by the distended and usually convoluted walls of the tube which are firmly adherent to all the parts about it, and especially to the ovary (pyosalpinx). In milder cases the disease may not progress so far as to produce a pus sac, but may cause obliteration of the uterine extremity of the tube, and then blood or serum may collect in the latter. In the former case we have hæmatosalpinx, in the latter hydrosalpinx. The inflammation may involve the ovary also, forming an abscess the cavity of which may communicate with that of the tube. These tubo-ovarian inflammatory cysts may also originate from the union of a pyosalpinx or hydrosalpinx with an ovary already in a cystic condition. The connection between the two may be the orifice of the tube or an abnormal lateral opening. In connection with inflammation of the tubes, abscesses are occasionally found in the pelvis developing in the peritoneal cavity or in the cellular tissue, or involving the ovary (Wharton and Curtis, 3d ed.). Any pathological condition or malformation of the tubes which prevents the passage of the ovule to the uterus, but which does not prevent the spermatozoa from passing to the ovule, may produce extra-uterine pregnancy. Women whose reproductive organs have never been subject to gonorrhœal or septic infection give the best promise of sex control.

The Vagina (Figs. 11, *a*, 13, 15) is a membranous canal, from three to six inches long, extending in a curve downward and forward from the neck of the uterus, which it embraces, to the external organs of generation. Its lining membrane is covered with stratified squamous epithelium, and contains a number of mucous crypts,

but no true glands. External to the lining membrane, the walls of the vagina are constructed of plain muscle and fibrous tissue, within which in the submucosa, more especially around the lower part of the tube, is a layer of erectile tissue. The erectile tissue exists also in the mucosa. The lower extremity of the vagina is surrounded by a band of striated muscular fibres, the sphincter vaginæ; its external orifice, when unruptured, is partially closed by a fold of mucous membrane, called the hymen. The mucous secretion of the vagina is acid in reaction, which is destructive to the spermatozoa. Although this is true, there are "occasional cases of pregnancy in which conception occurs through a minute opening and an almost imperforate hymen, and also one recorded case in which no apparent opening existed" (Edgar). The sexual union produces a flow of mucus from the mucous crypts in the wall of the vagina, through which the spermatozoa pass to the uterus before this mucus becomes acid in reaction. It is impossible for the human spermatozoa to pierce the normal mucous membrane.

"The external organs of generation in the female are the mons veneris, the labia majora and minora, the clitoris, the meatus urinarius, and the orifice of the vagina. The term 'vulva' or 'pudendum,' as generally applied, includes all these parts.

"The mons veneris is the rounded eminence in front of the pubes formed by a collection of fatty tissue beneath the integument. It surmounts the vulva and becomes covered with hair at the time of puberty.

"The labia majora are two prominent longitudinal cutaneous folds extending downward from the mons

veneris to the anterior boundary of the perineum, and enclosing an elliptical fissure, the common urino-sexual opening. Each labium is formed externally of integument covered with hair; internally, of mucous membrane, which is continuous with the genito-urinary mucous tract; and, between the two, of a considerable quantity of areolar tissue, fat, and a tissue resembling the dartos of the scrotum, besides vessels, nerves, and glands. The labia are thicker in front than behind, and joined together at each extremity, forming the anterior and posterior commissures. The interval left between the posterior commissure and the margin of the anus is about an inch in length, and constitutes the perineum. Just within the posterior commissure is a small transverse fold, the *frænulum pudendi* or *fourchette*, which is commonly ruptured in the first parturition, and the space between it and the commissure is called the *fossa navicularis*. The labia are analogous to the scrotum in the male.

“The labia minora or *nymphæ* are two small folds of mucous membrane situated within the labia majora, extending from the clitoris obliquely downward and outward for about an inch and a half on each side of the orifice of the vagina, on the sides of which they are lost. They are continuous externally with the labia majora, internally with the inner surface of the vagina. As they converge toward the clitoris in front each labium divides into two folds, which surround the glans clitoridis, the superior folds uniting to form the *præputium clitoridis*, the inferior folds being attached to the glans and forming the *frænum*. The *nymphæ* are composed of mucous membrane, covered by a thin epithelial layer. They

contain a plexus of vessels in their interior, and are provided with numerous large mucous crypts which secrete abundance of sebaceous matter.

“The hymen is a thin semilunar fold of mucous membrane stretched across the lower part of the orifice of the vagina, its concave margin being turned upward toward the pubes. Sometimes this membrane forms a complete septum across the orifice of the vagina—a condition known as imperforate hymen. Occasionally it forms a circular septum, perforated in the centre by a round opening; sometimes it is cribriform, or its free margin forms a membranous fringe, or it may be entirely absent. It may also persist after copulation. The hymen cannot, consequently, be considered as a test of virginity. Its rupture or the rudimentary condition of the membrane above referred to gives rise to those small rounded elevations which surround the opening of the vagina, the *carunculæ myrtiformes*.

“Glands of Bartholin.—On each side of the commencement of the vagina is a round or oblong body, of a reddish-yellow color and of the size of a horse-bean, analogous to Cowper’s gland in the male. It is called the gland of Bartholin. Each gland opens by means of a long single duct upon the inner side of the nymphæ, external to the hymen. (Occasionally these become inflamed or obstructed and cause retention-cysts or abscesses.)

“The clitoris is an erectile structure analogous to the corpora cavernosa of the penis. (It differs from the penis in having no corpus spongiosum and no urethra.) It is situated beneath the anterior commissure, partially hidden between the anterior extremities of the labia

minora. It is an elongated organ, connected to the rami of the pubes and ischia on each side by a crus; the body is short and concealed beneath the labia; the free extremity, or glans clitoridis, is a small rounded tubercle consisting of spongy erectile tissue and highly sensitive. The clitoris consists of two corpora cavernosa composed of erectile tissue enclosed in a dense layer of fibrous membrane, united together along their inner surfaces by an incomplete fibrous pectiniform septum. It is provided, like the penis, with a suspensory ligament and with two small muscles, the *erectores clitoridis*, which are inserted into the crura of the corpora cavernosa.

“Between the clitoris and the entrance of the vagina is a triangular smooth surface bounded on each side by the *nymphæ*; this is the vestibule.

“The orifice of the urethra (*meatus urinarius*) is situated at the back part of the vestibule, about an inch below the clitoris and near the margin of the vagina, surrounded by a prominent elevation of the mucous membrane. Below the *meatus urinarius* is the orifice of the vagina, an elliptical aperture, more or less closed in the virgin by a membranous fold, the hymen.” (Gray.)

It is necessary for the male organ to come into contact with the clitoris during the sexual union to produce orgasm in the female. This fact explains why some women remain in an apathetic condition during the sexual union, neither the body nor the glans being erect, and their erection is necessary before the sexual shock can be delivered. When it is desirable to rupture a Graafian follicle, the glans clitoridis must be erect, and this condition is present only in those women who are passionate, loving, and fond of their husbands.

In the very fleshy women (Fig. 15, *A, e*), a considerable quantity of fat is stored in the tissue adjacent to the clitoris, which prevents the male organ from coming in contact with it during the sexual union. When this is the case it prevents orgasm in the female and there is a consequent excessive production of girls or sterility.

CHAPTER IV.

THE SPERMATOZOÖN.

The Human Spermatozoön.—Each spermatozoön consists of three parts: a head, a middle part or body, and a long, slender, tapering tail (Figs. 16, 17). The heads are of several sizes and shapes, varying according to age: in the young, large and round; in the old, small and oval. The head, or nucleus, of the spermatozoön is clear whitish in appearance and remains so until disintegration takes place, unless it is stained by some reagent. It is covered with a very thin cytoplasmic envelope, the posterior part of which is overlapped by the sex membrane, to be described later. It represents the modified nucleus of the spermatid, and consists chiefly of chromatin, and so stains readily with nuclear reagents. The nucleus of the human spermatozoön is made up of granules arranged concentrically (Fig. 18, *I, II, b*). In some animals it bears a small barb-like projection, the acrosome, at its anterior extremity, by means of which the spermatozoön bores its way into the ovum. The acrosome in some animals is at times almost as large as the nucleus, while in others it is very minute, and in man it seems to be absent. The head of a normal spermatozoön, which has just become detached from the mother cell, or the large cell of Sertoli (Fig. 16, *I*), is very large and is almost perfectly round, being more elliptical in profile than those to be described later. In



FIG. 16.—HUMAN SPERMATOOA ON THE FLAT AND IN PROFILE.

n, The nucleus or head; *sm*, sex-membrane; *b*, body; *t*, tail; *e.p.*, end-piece. These are male-producing spermatozoa, those to the left are more decidedly so. Only the commencement of the tail is represented in the two which are shown in profile. 1, Upper surface; 2, lower surface. Note the convexity of the upper surface, and the concavity of the lower. Magnified 2,500 diameters.



FIG. 17.—HUMAN SPERMATOZOA ON THE FLAT AND IN PROFILE.

n, Nucleus or head; *sm*, sex-membrane; *b*, body; *t*, tail; *e.p.*, end-piece. These are female-producing spermatozoa. Only the commencement of the tail is represented in the two which are shown in profile. 1, Upper surface; 2, lower surface. Note the convexity of the upper surface, and the concavity of the lower. Magnified 2,500 diameters.

semen which has been allowed to accumulate in the vesiculæ seminales for eight or ten days, we find a number of spermatozoa, some dead, some just able to move, which on examination show the head to be much smaller (Fig. 17, *I, II*) than those above described. The antero-posterior diameter is shorter, the head is oval in shape, almost pointed anteriorly, in profile (Fig. 17, *I, II*) it is narrow and pointed at its free end, and the sex-membrane apparently runs farther up and covers more of the anterior part of the head, from one-half to three-fourths or more of its surface. This is not the case in the young spermatozoön. The sex-membrane to which I refer above is not described by others.

The sex-membrane (Figs. 16, 17, *sm*) is a thin envelope, covering and fitting perfectly the posterior one-fourth to four-fifths of the nucleus of the human spermatozoön. This membrane is continuous with and covers the body or middle-piece, tail, and end-piece. It fits over the posterior part of the nucleus like the cup over the acorn. The head, or nucleus, of the spermatozoön contains the nutriment from which the spermatozoön is fed during its life. As the spermatozoön grows old or begins to move about, this nutriment is gradually used up, with a consequent shrinking of the head. The protoplasm stored in the nucleus of the spermatozoön is the constituent consumed and not the chromatin. In some the body near the head then looks as if it were pyramidal in shape, but the appearance is due to the shrinking of the sex-membrane to the smaller nucleus. At the same time the membrane will reach farther forward toward the free end of the nucleus and thus cover more of the nucleus when it becomes old and small.

The sex-membrane maintains its size from the time the spermatozoön becomes detached from the Sertoli cell until the death of the spermatozoön. This membrane is derived from the unmodified cytoplasm of the spermatid, and is held in position by a viscid substance, by at least three of the axial filaments (Fig. 18, *a*) which pass into the substance of the nucleus and may be given

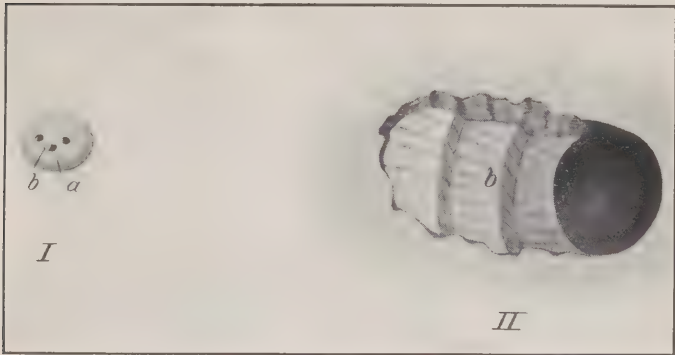


FIG. 18.—THE NUCLEUS OF A HUMAN SPERMATOZOÖN.

I, Nucleus of the spermatozoön with the sex-membrane removed. Note the three openings from which the axial filaments were extracted. *a*, Opening made by the extraction of one of the axial filaments; *b*, laceration of the nucleus from the extraction of the filament. *II*, The laceration highly magnified. Note the concentric arrangement of the layers of the nuclear substance and their division into sections.

off from the end-knobs in the anterior part of the body, by its very slight contractility, and by its perfect proximity to the thin, dense, smooth, whitish, clear, cytoplasmic envelope of the nucleus. When the nucleus is dislodged from the sex-membrane, it is perfectly smooth and uniform in contour, and no part or particle of the sex-membrane remains attached to it. The inner surface of the sex-membrane which comes into contact with the

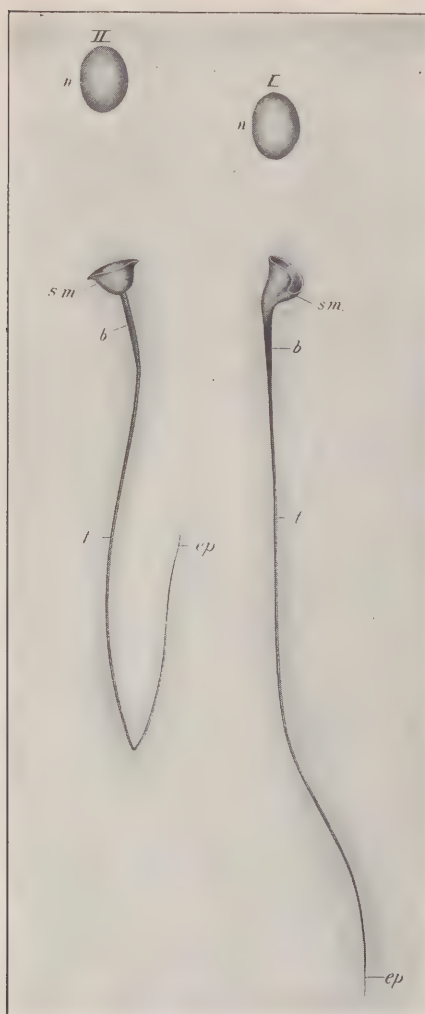


FIG. 19.—HUMAN SPERMATOCYTES.

Showing detachment of the nucleus. *sm.*, Sex-membrane, with the nucleus detached; *b*, body; *t*, tail; *ep*, end-piece. Magnified 2,000 diameters.

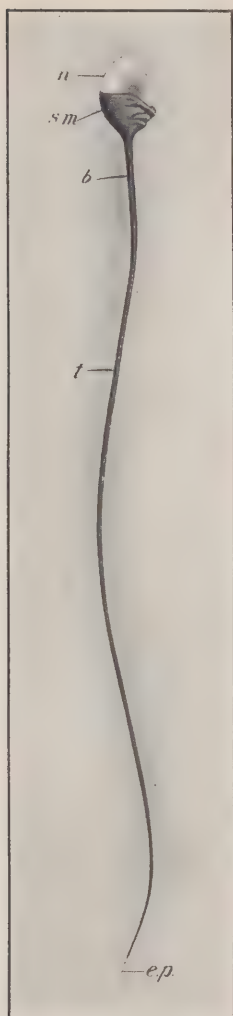


FIG. 20.—HUMAN SPERMATOZOÖN.

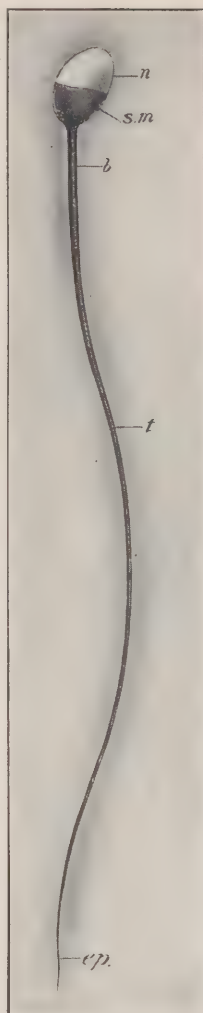


FIG. 21.—HUMAN SPERMATOZOÖN.

FIG. 20.—Sex-membrane pushed back on the nucleus. *n*, Nucleus; *sm*, sex-membrane, pushed back from one side of the nucleus; *b*, body; *t*, tail; *ep.*, end-piece.

FIG. 21.—*n*, Nucleus, left axial filament broken, causing its deflection to the right; *sm*, sex-membrane; *b*, body; *t*, tail; *ep.*, end-piece.

nucleus is somewhat granular in appearance; it is not so smooth and homogeneous as it is on the outside. The sex-membrane does not collapse in every case when the nucleus is removed from it, but the peripheral border sometimes rolls back very slightly (Fig. 19, *II*). In some cases it will partially collapse, as shown in Fig. 19, *I*.

This membrane is occasionally pushed back on the nucleus, as shown in Fig. 20. As soon as one of the axial filaments which pass from the end-knob into the nucleus is broken or detached from the inner structure of the nucleus, all motion ceases. The breakage may be due to the spermatozoön trying to enter a hard substance, or striking it with its head; in such a case the nucleus is deflected from the side of the detached or broken filament (Fig. 21), but still remains in the sex-membrane. The sex-membrane is not conspicuous in the living spermatozoa, but becomes so from twelve to eighteen hours after their death, when it assumes a yellowish-green color, and is seen to be continuous with the covering of the body and tail. The sex-membrane is subject to the same changes from reagents as the external envelope of the body and tail.

The staining is more decided in the nucleus immediately under this membrane, and is caused by capillary attraction from the close juxtaposition of the two membranes, and not by the staining of the membrane itself. When the nucleus or head of the spermatozoön is small from any cause the sex-membrane covers the greater part of it and hence the membrane extends farther forward, so that when the spermatozoön makes an entrance through the vitelline membrane of the ovum,

the nucleus is hugged tightly by this very elastic vitelline membrane, which clashes with the sex-membrane and strips it off, leaving it outside. Now in the production of a male, the sex-membrane is posterior to the largest part

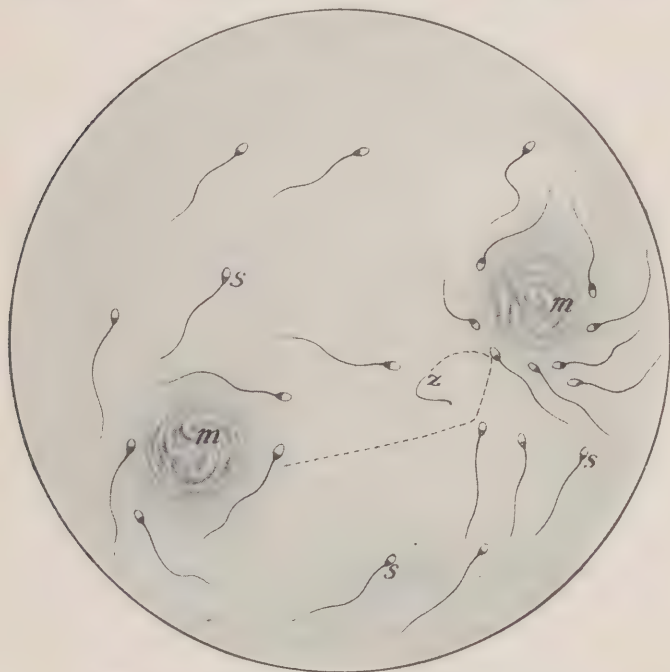


FIG. 22.—MICROSCOPIC FIELD OF HUMAN SPERMATOZOA.

The dotted line indicates the course taken by the sex-membrane, body, and tail, which had been detached from its nucleus. *z*, Part of the spermatozoön last seen; *m*, mucous clots; *s*, spermatozoa.

of the nucleus or head, and when the nucleus passes through the vitelline membrane into the protoplasm of the ovum, the sex-membrane is not touched or impinged upon by the vitelline membrane, in which case the head,

body, tail, and end-piece all go in and become embedded in the cytoplasm of the ovum. The tail is quickly absorbed by the cytoplasm, while the nucleus and probably the middle-piece persist as distinct structures or until maturation of the ovum shall have been completed, then they are absorbed and become attracted to and form part of the aster and nucleus of the zygote.

I first saw the sex-membrane in a field of human spermatozoa, where ten or fifteen had congregated and were moving very actively, a little below and to the left of the centre of the field (Fig. 22). While my sight was fixed on a group a little to the right and above the centre of the field, I saw moving from the lower congregation one without a nucleus, its sex-membrane being folded back on the body (Fig. 23). In trying to follow it with the focus of the glass, it was forced from the field and I could not find it again. In this case, the nucleus had been torn from the sex-membrane and the body, probably by a blow from another spermatozoon or by contact with some hard substance. I did not see the nucleus after its detachment from the sex-membrane. After making many examinations I again saw in an open field a specimen in which the nucleus had been torn from the sex-membrane; and the nucleus was lying about one and a half times the length of a spermatozoon from the membrane (Fig. 19, *I*). Again, after examining many slides and searching many fields, I was rewarded by finding a perfect specimen of the sex-membrane detached from the nucleus. The nucleus in this case was lying about the length of a spermatozoon from it (Fig. 19, *II*). The fact that the nucleus was found near the sex-membrane goes to indicate very little movement after the

separation. I find that the sex-membrane may be detached from the nucleus by tapping the cover glass several times with a small piece of metal. In some specimens of semen containing old, small-headed, female-producing spermatozoa, it may be accomplished very readily; while in other specimens containing large-headed, male-producing spermatozoa, it is very hard to obtain the desired result.

The middle part, or body, is a short cylindrical or conical piece, lying behind the head and giving attachment to the tail, from which it is not always distinctly marked off (Fig. 16, *b*), a line of demarcation being the exception. In the young spermatozoön which has just become detached from the nurse cell, or Sertoli cell, the body is long and cylindrical, with no well-defined line of demarcation be-

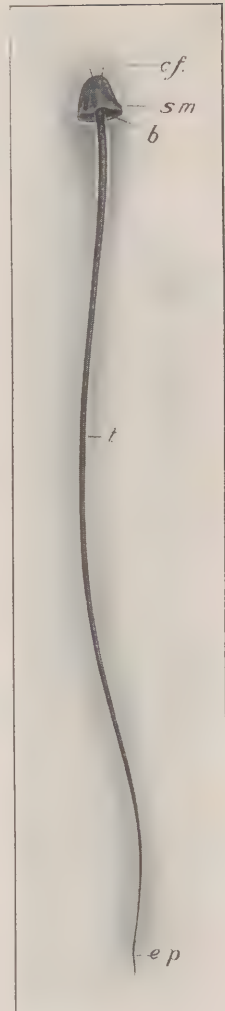


FIG. 23.—*cf.*, Connecting filaments. There being only two filaments shown in this specimen, it is probable that the greater part of one was broken off near the surface of the nucleus. The laceration of the nucleus (Fig. 18, *b*) shows one to be more thoroughly attached than the other two; in this case it might have been bent back and placed in contact with the sex-membrane, owing to the resistance of the medium through which it passed. *sm*, Sex-membrane, inverted; *b*, body; *t*, tail; *ep*, end-piece.

FIG. 23.—THE SEX-MEMBRANE OF THE HUMAN SPERMATOZOÖN.

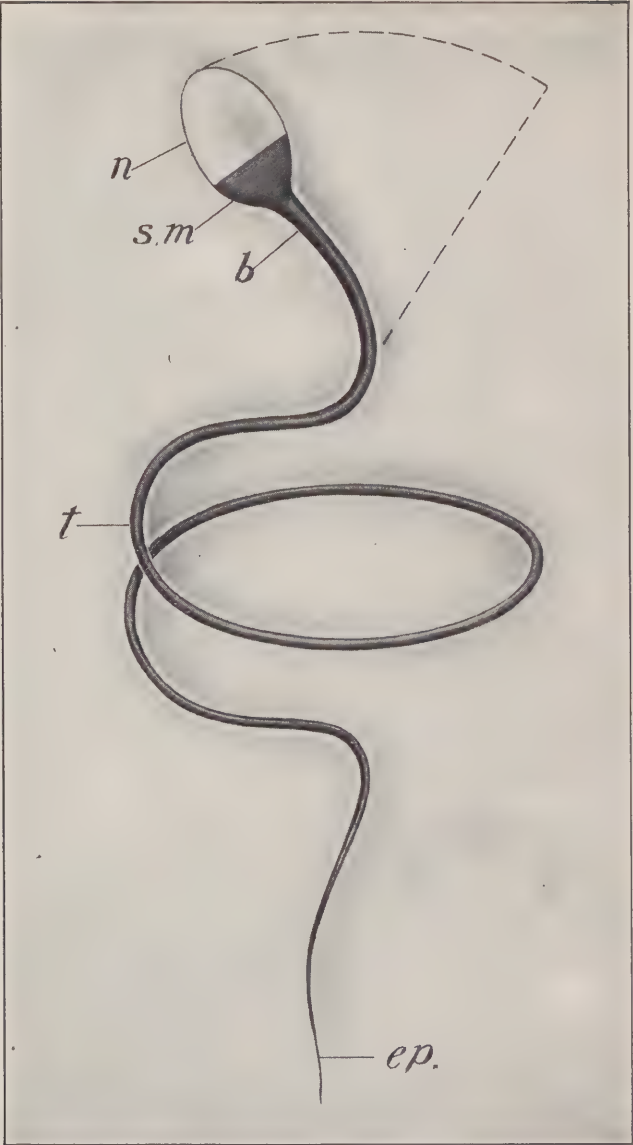


FIG. 24.—HUMAN SPERMATOZOÖN. (Description on opposite page.)

tween it and the tail. In a few of those which have been detached from the nurse cell for some time, the body becomes conical and the line of demarcation more distinct. The covering, which has been described as the sex-membrane, is continuous with the tail cover and with part of the head.

"The middle piece either contains a formed centrosome, or a pair of centrosomes (end-knob), or is itself a metamorphosed centrosome. This is probably to be regarded as the fertilizing element par excellence, since there is reason to believe that when introduced into the egg it gives the stimulus to division" (Wilson). The presence of this powerful stimulant to cell-division and cell-formation in the male explains the secret of the larger size of the male as compared with the female, and also the multiplicity of the primordial cells (the spermatozoa) produced and given off each day, while there is but one (the ovum) given off each month in the female. The centrosome is the most active particle entering into cell-formation, and it is very probable that each and every particle forming a part of the apparently insoluble body (as mentioned by Sobotta, in his specimen of fertilization of the ovum of a rat) ultimately becomes active and forms the centrosome, which brings out the paternal characteristics. This begins to dominate after the male has attained the age at which the female is considered grown, the centrosome previous to this having been developed from the more active centrosome in the ovum.

The body shows the same staining reactions as the

FIG. 24.—A characteristic shape and method assumed by some spermatozoa in making search for the ovum. It swings its head back and forth across the medium in which it is located, as indicated by the dotted line. *n*, Nucleus; *s.m.*, sex-membrane; *b*, body; *t*, tail; *e.p.*, end-piece. Magnified 5,000 diameters,

acrosome, having an especial affinity for "plasma-stains" (acid fuchsin, etc.). At its front end, it is in some mammals separated from the nucleus by a short clear region, the neck. Like the acrosome, the middle piece is in some cases derived from an "archoplasmic"

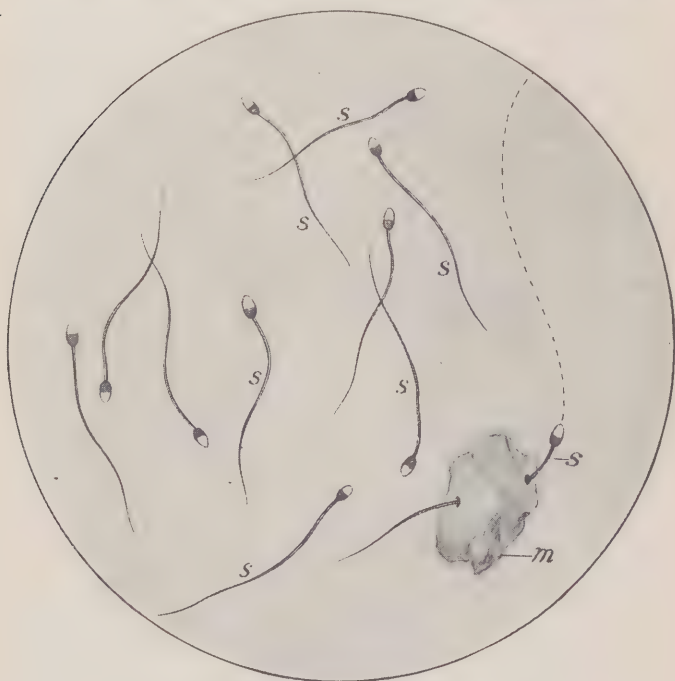


FIG. 25. —MICROSCOPIC FIELD OF HUMAN SPERMATOOA.

m, A clot of semisolid mucus, through which the spermatozoön, as indicated, bored its way. Dotted line indicates course taken after passing through clot. *s*, Spermatozoa.

mass, representing an attraction-sphere (*Lumbricus*), or a portion of the *Nebenkern* (insects), and it contains, or according to some authors actually arises from, the cen-

troosome (salamander, mammals, insects, etc.) (Wilson). The spermatozoön has the power (Figs. 24, 28), by bending its body, to strike a downward, upward, or side blow, or to strike any intermediate point. It can move its body most gracefully in a circle.



FIG. 26.—HUMAN SPERMATOZOA.

Spermatozoön in a characteristic position making search for the ovum. The time consumed in making a circuit was about eight seconds, after which it remained in the centre of the field for fifteen minutes. Apparently the circuits were made in search for a current.

The tail is the longest part of the spermatozoön (Fig. 16 *t*), measuring about five or six times the combined lengths of the head and body. Its terminal portion is

extremely slender, and forms a distinct part of the spermatozoön, the end-piece (Fig. 16, *e.p.*). It consists of a fibrillated axial filament, surrounded by a cytoplasmic envelope or extension of the sex-membrane. The

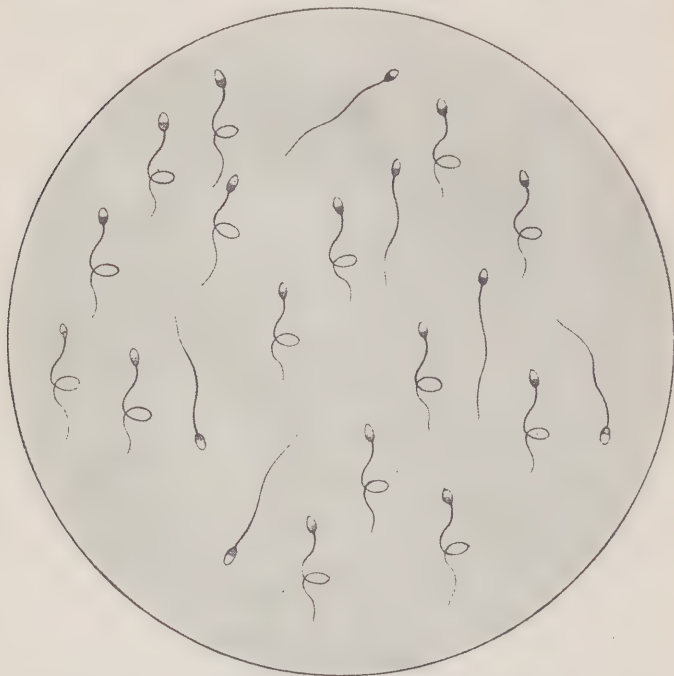


FIG. 27.—A MICROSCOPIC FIELD OF HUMAN SPERMATOZOA.

In a characteristic coiled position, making search for the ovum by swinging the head to and fro across the current of the medium in which they are situated.

axial filaments are outgrowths from two or three of the spermatid centrosomes. The tail envelope or sex-membrane arises either from the archoplasm of the Nebenkern (insects), together with a small amount of unmodified cytoplasm, or from the latter alone. The axial

filament, acting as a vertebra, imparts stiffness to the body and tail, and probably serves or aids in conveying nutriment from the nucleus to the membranes of both body and tail. "In all animals there is a certain amount



FIG. 28.—A FIELD OF DEAD FEMALE-PRODUCING SPERMATOZOA.

a, b, c, d, e, Characteristic relation assumed upon the approach of death of the spermatozoön. *f*, A female-producing spermatozoön trying to enter a fixed leucocyte. This struggle was made for two and a half hours, striking the leucocyte in the same place each time and resulting in the groove as indicated.

of work done in the daily life, and the energy put into such work comes from the oxidation, or from physiological burning, of the protoplasm. There is, therefore, a

constant waste of protoplasmic material which goes off as work done, as heat, or as residual waste matter comparable with smoke and ashes of physical combustion. Such waste is made good by the addition of new raw

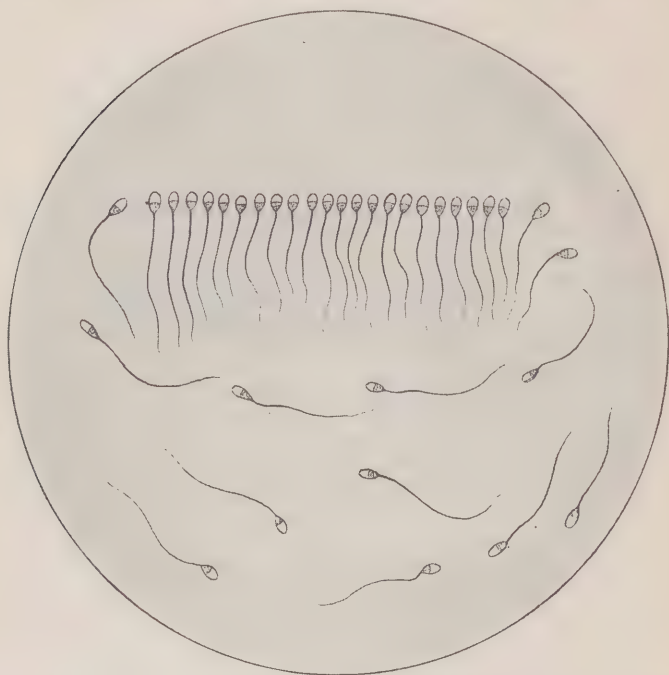


FIG. 29.—AN INTERESTING FIELD OF HUMAN SPERMATOZOA.

In this case, there seemed to be, in front of the spermatozoa in the line, an obstruction which they tried to pass. In trying to make a passage they worked their way from left to right about once every three minutes.

materials in the form of blood, which is made over into new protoplasm " (Calkins), in all unicellular animals except the spermatozoa. The movements of the body and tail are carried on at the expense of the nutriment

stored up in the nucleus. Owing to the minuteness of the parts in question it remains to be explained just how the nutriment is distributed to them; perhaps it is, under the law of osmosis, facilitated by the constant movements of the spermatozoön. Nature has so arranged it that the nutriment or food from which a spermatozoön is developed is delivered to it in such a way that it may be taken up and stored in the nucleus with the minimum effort on the part of the spermatozoön. After its detachment from the nurse or Sertoli cell, it is never again so situated; and the probability of its taking up food after its separation is very remote indeed. This being the case, the food stored up in the spermatozoön is then consumed; and the head, being the reservoir, is gradually drawn upon until it becomes slim and pointed at its free end, instead of large, round, and club-shaped (Figs. 16, 17). Some of the nurse cells are smaller than others and not so favorably situated as to procure and deliver food to the spermatozoön, in which case the nucleus of the spermatozoön is not so large and well filled as one from a large and more favorably situated mother cell. Again, it occurs that very many spermatozoa—from eight to sixteen or according to Kölliker twenty—are attached to one nurse cell (Fig. 6, 6, 7), when there will be a diminution in the size of the heads of the spermatozoa, as it is not possible for one mother cell to do for sixteen to twenty what it could do readily for from four to eight (Fig. 6, 1, 2). When a great number of spermatozoa are attached to one nurse or Sertoli cell, room becomes limited before each nucleus has reached its normal size and detachment is unavoidably produced at an early period in the life of the spermatozoön while it is still

small, owing to the limited space and quantity of nutriment that had to be divided among so many. The giant or large spermatozoa are produced when there are only from four to eight individuals attached to the nurse or Sertoli cell. The multiplicity of spermatozoa to a single nurse cell is more often met with when there is a rapid spermatogenesis. This is the reason the young male is more liable to female-production. Again, when there is an increase of blood-pressure in the testicle of the older man, it is liable to produce detachment of the spermatozoön from its mother cell before the nucleus is filled to its maximum capacity. The blood-pressure in the testicle is increased by sexual desire which may arise from psychical or ocular impressions, from mingling with females, from the consumption of a large quantity of highly nutritious foods, more especially the nitrogenous, or from various drugs.

From a sexual point of view we may arrange the parts of the spermatozoön under two categories as follows:

1. *The essential structure which plays a direct part in the production of the female, the nucleus* (Fig. 17, n, 18, I, 19, I, II), which contains the chromatin and probably one or two centrosomes, is all that is forced through the vitelline membrane and delivered to the cytoplasm of the ovum for the production of a female.

2. *The essential structures which play a direct part in the production of a male: the nucleus, body, and tail* (Fig. 16, n, b, t, e.p). The nucleus, with one or two small centrosomes which are augmented by the body and all of the axial filament, enters the cytoplasm of the ovum. As the axial filament has been developed from a peripheral centrosome, there is no doubt that it is homologous

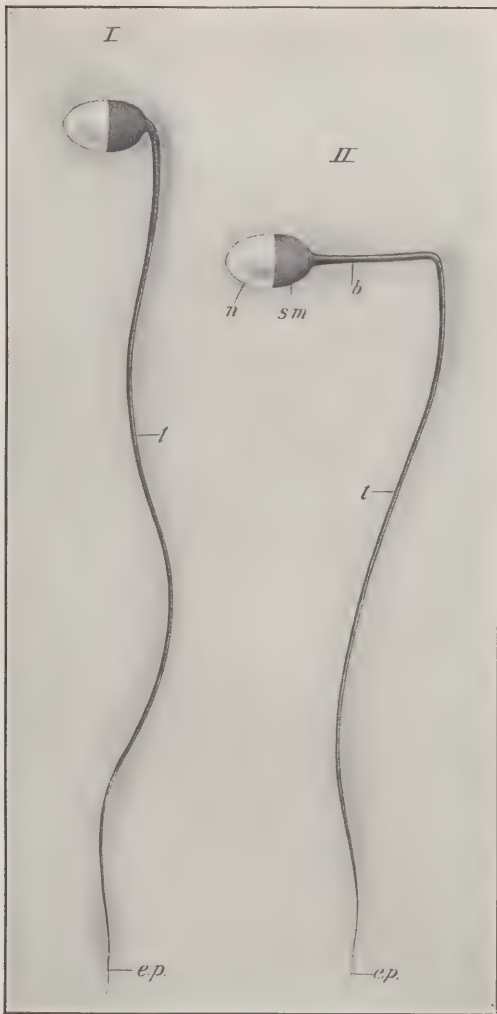


FIG. 30.—HUMAN SPERMATOZOA DEFORMED.

I, Frequently seen in a field of spermatozoa; *II*, deformity seen less frequently;
n, nucleus; *s.m.*, sex-membrane; *b*, body; *t*, tail; *e.p.*, end-piece.

to the centrosome. To produce a perfect male specimen, I am of the opinion that it is necessary for the tail of the spermatozoön to enter into and form a part of the first complete cell (zygote) which ultimately goes to produce the animal.

The spermatozoa with large round heads are very active, so active indeed that it is scarcely possible to follow them with the eye when they are under a high-power microscope. They live from six to eighteen hours under the cover glass, at a temperature of 60° Fahr. Those with oval heads or with heads pointed at the free end, in other words those with smaller nuclei or old spermatozoa, cease to move in a few minutes after remaining under the cover glass. The fact that the large-headed spermatozoa move faster and live longer, and that the small-headed move more slowly and die sooner, demonstrates beyond a doubt that the former are the young, and the latter the old. In studying some of their movements in a slow or rapid current of the medium, some of the young and old will go down the current, while others will make a terrific struggle to go up current, it matters not how rapid the movement of the medium. When the cover glass is in close juxtaposition with the slide, the spermatozoa move about continually in search for an ovum by swinging the head right and left, which is done by bending the body and a very small part of the tail nearest the body. This motion is not made to assist in locomotion, in fact it retards it. It is made for the sole purpose of extending and enlarging the path of search for the ovum. While the above is the usual method, some make the search by coiling the lower three-fourths of their tail one and a half times (Figs.

24, 26, 27), the head and body, in an erect position, swinging to and fro across the current when there is one in the medium — a mode of search which requires the minimum energy and power. When the coiled spermatozoa pass from a lower to a higher stratum of the medium, they do so by moving in a spiral direction, making the ascent without the slightest visible effort on their part. Some of the spermatozoa which assume the coiled position to make search for the ovum, when changing their field of search, straighten themselves out and move in a straight line, without a visible movement of their head, body, or tail, and going with great rapidity and apparent ease. It is only the largest and best

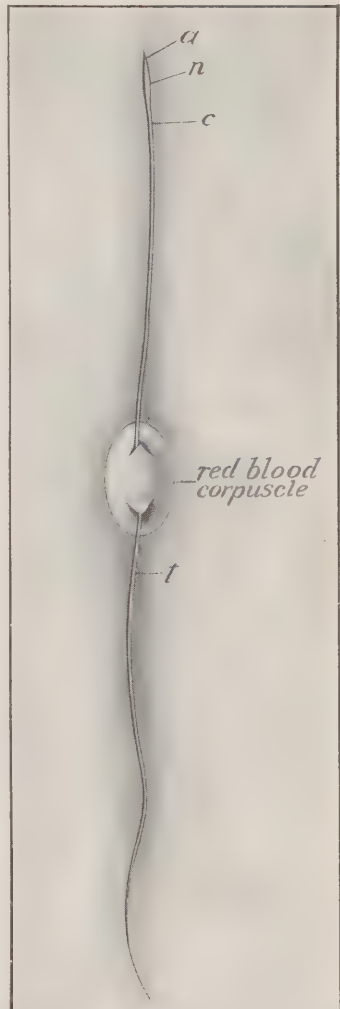


FIG. 31.—*a*, Acrosome; *n*, nucleus; *c*, cervix; *t*, tail; a red blood corpuscle pierced as indicated by the spermatozoön.

FIG. 31.—A SPERMATOZOÖN OF A COCK SEEN IN A SPECIMEN OF SEMEN TAKEN FROM A TESTICLE RUPTURED BEFORE THE DEATH OF THE COCK.

specimens that assume the coiled position in their search for the ovum, though both male and female producing spermatozoa assume this position and use this method.

If the cover glass is in close juxtaposition it prevents the spermatozoön from assuming the coiled position. To make a successful search for this kind of spermatozoön it is necessary to insert a hair under one side of the cover glass.

The giant spermatozoön is occasionally met with in the semen of some men. Identical twins are undoubtedly produced by the giant spermatozoön, or a very large ovum, otherwise nature could not prevent the production of a giant, which would be destructive to the life of the mother.

The medium through which the spermatozoa pass and in which they remain, plays a considerable rôle in their movements, the duration of their male-producing quality, and the length of their life. When the semen has been allowed to remain in the vesiculæ seminales for eight or ten days before ejection—in some males all the time regardless of the ejection, in others only occasionally—it becomes thick and tenacious, and thus retards the spermatozoa in their movements to just the extent of the viscosity of the medium; for when the semen is viscid from any cause, more or less of the secretion adheres to them, and if such a load is to be dragged along it sometimes requires great effort on their part to move at all. In some cases, when a large tenacious mass of mucus adheres to them, they become fixed. Inasmuch as the nucleus or head is the storehouse for the cell nutriment, it is rapidly consumed in a condition as above



FIG. 32.—SPERMATOZOA OF A COCK LESS THE NUCLEUS.

a, a, a, a, The sex-membrane.



FIG. 33. —A FIELD OF SPERMATOOA FROM THE COCK.

a, b, c. Characteristic bundles of sixteen spermatozoa seen in semen when taken from the seminiferous tubules of the testicle.

described. The same physical law is exemplified in the case of a wagon or automobile which on a smooth, dry road runs readily and easily with a minimum consumption of power; but as soon as it passes into a thick, tenacious, muddy road, the wheels become clogged with mud, progress is retarded, and more motive power is consumed. A thick tenacious secretion may be encountered by the spermatozoa at any point, near the mother or Sertoli cell in the seminiferous tubules, as well as in the spermatic cord, the vesiculæ seminales, the vagina, uterus, or Fallopian tubes.

I once observed a human spermatozoön penetrating a small clot of mucus of considerable density. The entrance was effected by an upward-downward movement of the head alternating with a side-to-side swinging (Fig. 25), and an occasional circular movement. Thus the size of the opening was increased in all directions until the nucleus or head and about one-fourth of the body were covered by the mass of mucus. After that it remained quiet for about thirty seconds, and then resumed the movements as above described until it pierced the opposite side of the clot, when it continued its search for the ovum in another section of the field.

CHAPTER V.

THE OVUM.

The Primitive Ovum.—The primitive ova arise from cells of the mesothelium (peritoneal epithelium) covering the genital ridge of the embryo. The ridge gives rise to the mature ovary (Fig. 1, *l*). On account of its function the epithelium of the genital ridge has been called the germinal epithelium. Both the ova and the epithelium of the Graafian follicles originate from the germinal epithelium as above described. The latter forms at first a simple layer covering the stroma, and by its further development becomes thickened and multiple. Certain cells of the germinal epithelium become larger than the others, and these cells are soon carried into the stroma of the ovary by being included in cord-like ingrowths of the epithelium. These cords of epithelial cells are Pflüger's egg tubes (Fig. 34, *A*). The primitive ova exist in multiple in the cords, each of them becomes surrounded by a separate envelope of epithelial cells (Fig. 34, *B*). A little later each ovum separates from its neighbor and appears as a round cell with a clear nucleus and distinct nucleolus. They are closely invested at first by a single layer of flattened cells smaller than the ovum itself. The young egg-cell, together with its epithelial envelope, constitutes the so-called primordial follicle (Fig. 34, *B*, *C*).

Growth and Development of the Ovum.—The ovum enlarges until mature, when it becomes much larger



FIG. 34.—FIGURES SHOWING VARIOUS STAGES IN THE DEVELOPMENT OF THE GRAAFIAN FOLLICLE OF THE RABBIT.

A, From ovary of young rabbit, showing "egg-tubes" of Pflüger growing in from germinal epithelium; some of the tubes contain primitive ova; B, primitive Graafian follicle, with a single layer of follicle-epithelium; C, a young Graafian follicle, with a single layer of follicle-epithelium; D, a somewhat older follicle, with the second layer forming within the first; E, a more advanced follicle, showing two complete layers of columnar epithelium surrounding the ovum within the follicle.

than any other cell in the body of the parent. It usually becomes quite spherical. The shape of the egg does not necessarily remain spherical, but may be altered by external pressure. The nucleus becomes large and spherical and assumes an excentric position within the ovum. The cellular network becomes very distinct, and its meshes become filled with ovoid or crystalline solid enclosures, which are of an albuminoid character. The enclosures form the part which is called the deutoplasm. The deutoplasm is the same as the yolk-substance of the earlier writers, and it is a store for nutritive material from which the protoplasm draws subsequently to support its growth. In all vertebrates an ovarian envelope, the *zona radiata*, is formed (Fig. 35, *z*). The vitelline membrane is always formed inside the *zona radiata* by the ovum before it reaches maturity.

Primordial Ovum.—The ovary at birth and up to the climacteric period contains small egg-cells, some of which develop from time to time into mature ova. These small egg-cells together with their follicles present a constant appearance at all ages. These egg-cells or ova are the primordial ova, which lie in the stroma of the ovary immediately below the albuginea and never in the medullary region. They are slightly irregular globules, the diameter of which is about one-third that of the mature ova. The protoplasm is finely and evenly granular and consists of a uniformly clear matrix and a very fine reticulum. Yolk granules have been found in the primordial ova of birds and various mammals; but this is not the case in man. The protoplasm is naked—there is no special cell membrane. The nucleus is round

and bounded by a very distinct membrane and lies in the centre of the cell; it contains a round excentrically placed nucleolus. There is a loose network of fibres in the nucleus, which is different from that of the nucleolus, as is shown by its different staining. Each primordial ovum is surrounded by a very thin epithelial envelope, with scattered fusiform nuclei.

Growth of the Ovum and Primary Follicle.—The follicles remain for a long time without change, but from time to time certain ones of them develop. In a mature ovary we can always find several stages. The cause of the development of the follicles is unknown. The primary follicles are always near the surface, but as they grow in size they move deeper into the stroma (Fig. 12). The first step is the multiplication of the cells of the follicle (Fig. 34, *B*, *C*, *D*) which converts the follicle into a layer of cubical cells with the nuclei at an even height. During this change in the follicle the primordial ovum does not alter in size.

The second step is the elongation of the cells into a cubical form, with an accompanying enlargement of the ovum. The growth of the ovum affects the protoplasm, the nucleus, and the nucleolus, all of which increase their dimensions. The follicular wall steadily increases in thickness. At first it remains single-layered, but the nuclei take their places at various levels, and a little later it becomes several-layered, and then the formation of the first envelope (*zona pellucida*) around the ovum begins. During the growth of the follicle there is a network of blood-vessels formed around it. The layer of blood-vessels constitutes the *tunica vasculosa* or *theca folliculi*. The first vessel is a single loop which embraces the

follicle; other loops approach and unite with their fellows to form a network.

After the epithelium of the primary follicle has developed into many layers, there appear in it rounded vacuolated spaces which increase in size and finally become confluent, so that there is a fissure formed in the epithelium. This fissure divides the epithelium into two layers, an inner one immediately surrounding the ovum, and an outer one next the stroma of the ovary. Since the fissure is incomplete around the follicle there is one place where the two layers are united (Fig. 12, *i*). The place of union, though variable in position, is always on the side of the follicle away from the surface of the ovary. This fissure is filled with serous fluid known as liquor folliculi. The appearance of the fissure changes the primary into a Graafian follicle.

The Graafian follicle is bounded by a layer of epithelium known as the membrana granulosa. To a part of its walls on the side away from the surface of the ovary is attached a mass of cells more or less globular in shape. This mass is known as the discus or cumulus proligerus. It encloses the ovum.

The Ovum.—The ovum or female gamete is a large cell, in fact the largest in the body, in most cases visible to the naked eye even in the ovary (Fig. 35), while the spermatozoön or male gamete is invisible and the smallest nucleated cell produced in the body. The female gamete or ovum is a non-motile, passive cell, which is wholly dependent upon the ciliated epithelium of the Fallopian tube to be picked up and wafted into the uterus for further development, while the spermatozoön possesses the power of active movement, and by its inherent power

makes its way from the mother cell (cell of Sertoli) in the seminiferous tubule to the vesiculæ seminales, a distance of thirty or forty feet. From the vagina after insemination it swims out of the masculine seminal

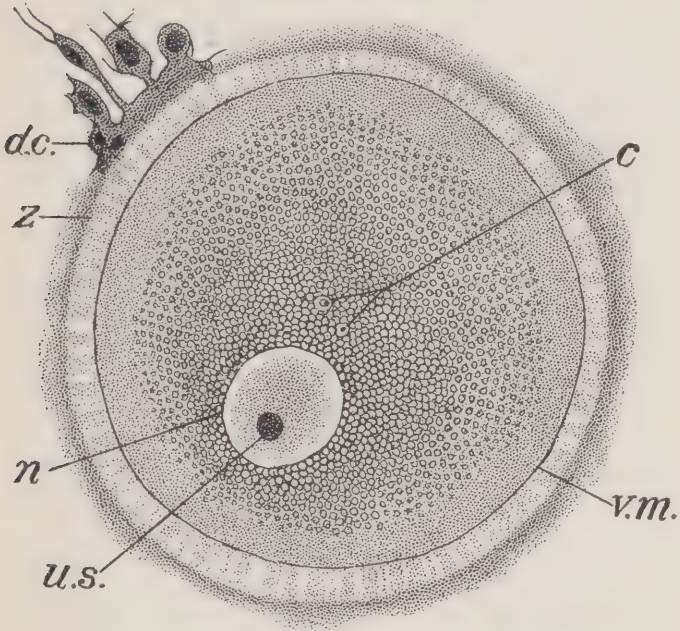


FIG. 35.—HUMAN OVUM; HIGHLY MAGNIFIED.

z, The zona pellucida, showing the faint striæ and a few cells of the discus proliferus, which are adherent to it; *v.m.*, vitelline membrane; *c*, centrosomes; *n*, nucleus; *u.s.*, nucleolus; *d.c.*, cells of the discus proliferus.

medium into the maternal secretions to the upper part of the Fallopian tube, where it meets the ovum and makes its way through the membranes into its cytoplasm. The ova are usually spherical in shape, which renders their transportation by the cilia from the ovary to the

cavity of the uterus more sure and easy. Each ovum contains a large nucleus, a centrosome, and a large quantity of protoplasm, and is enclosed in a stout very elastic membrane, which may, or may not, have a special aperture known as the micropile.

The Micropile.—When the ovum is surrounded by a protective envelope before fertilization it is usually perforated by one or more openings known as micropiles, through which the spermatozoön makes its entrance. Where there is but one micropile it is more often situated near the upper or anterior pole (fish, and many insects), but it may be situated at the opposite pole (mollusks and some insects). In some insects it is situated on the side. In the eggs of many insects there is a group of half a dozen or more micropiles near the upper pole of the egg, in which case more than one spermatozoön may enter the egg, though only one is concerned with the process of fertilization. The micropile has not been isolated in the enveloping membrane of the mammalian ovules, and its presence in them is very doubtful.

Membranes.—The coverings of the ovum may be arranged in four groups. They are:

(1) The vitelline membrane, which is formed by the ovum itself.

(2) The zona radiata, which is formed outside the ovum by the secretion of the follicle-cells.

(3) Accessory envelopes, secreted by the walls of the oviduct.

(4) Coverings secreted by the accessory glands.

(1) The Vitelline Membrane (Fig. 35, *v.m.*).—The vitelline membrane is a very thin, clear, tough, and elastic membrane immediately investing the yolk, being separat-

ed from the zona by a narrow space, and is a product of the ovum itself. It is formed a short time before the ovum matures, and is most distinct at the time of the formation of the polar bodies. The presence of this membrane is doubted by many writers, but its existence has been demonstrated. The entrance of the spermatozoön into the cytoplasm after it reaches the ovum is accomplished only after a prolonged hard struggle on its part. That there is a very stout elastic membrane enveloping the ovum may be demonstrated by placing an ovum upon a slide and covering it with a cover glass, by making a little pressure it can be compressed until it is comparatively flat, and immediately upon releasing the pressure it will resume its characteristic shape (spherical). Piersol speaks of this membrane and says, "The liberated ovum is surrounded by a protecting membrane, the zona pellucida, which sometimes exhibits a faint radial striation. This envelope must not be confounded with the vitelline membrane, since it is not strictly a part of the ovum, but a product of the surrounding epithelial cells lining the little sac, the Graafian follicle, enclosing the egg while within the ovary." Minot says, "Considerable doubt in regard to the presence of this membrane in vertebrates, and especially in mammals, has been expressed by various writers, but its existence seems to me to have been sufficiently demonstrated."

It is this tough elastic vitelline membrane with which the sex-membrane of the spermatozoön clashes in case of female-production. The tougher this membrane the greater the probability for female-production, for these reasons: (1) The continued struggle reduces the size

of the nucleus. (2) When the spermatozoön passes slowly through this membrane into the cytoplasm the chance is increased that the sex-membrane will be stripped off the nucleus. (3) The hugging of the nucleus more tightly by a more elastic membrane on its entrance into the cytoplasm would increase the chance that the sex-membrane will be stripped off.

(2) The Zona Radiata (Fig. 35, z).—The zona radiata is a transparent membrane, varying in thickness, which appears as a clear bright ring under the microscope. This membrane is pierced by very faint, clear, radiating pores, which produce the appearance to which the term zona radiata refers. *The faint striations are probably due to the passage of the more thin, clear nutriment from the cells of the discus proligerus through the zona radiata to the ovum. The faint striations are produced by the difference in color or in the refractive power of the old viscid secretion, the latter of which has been received immediately from each cell of the discus proligerus. It is probable that both the ova and the cells immediately investing it, contribute to the formation of the zona pellucida, and that it is formed from the waste products.* All writers agree that the spermatozoa can enter the zona radiata and swim around in it with apparent ease and freedom. This fact in itself makes it evident that this is not a tough or an elastic membrane. Any one who has ever studied the physical power of a spermatozoön knows that it cannot swim around in the stroma of a tough elastic membrane. This membrane, through which the spermatozoa move and swim freely, serves as a protection to them while making entrance into the cytoplasm of the ovum, by preventing them from being wafted away from the ovum in its progress through

the Fallopian tube. It has been frequently stated that a few of the cells from the discus proligerus remain attached to the ovum on its extrusion from the Graafian follicle. The extrusion of an ovum from its follicle has never been witnessed under normal conditions, and it is improbable that the cells remain intact in the fully developed ovum. The premature removal of the ovum from its follicle would, however, augment the chance for some of the cells from the discus proligerus to remain in contact with it.

The ova of mammals receive the deposit of the follicular secretion only as above mentioned. There are some eggs that are naked and remain so throughout their development (certain of the cœlenterates), while there are others that develop the vitelline membrane almost instantaneously upon fertilization (the entrance of the spermatozoön), of which the sea-urchin is a type.

(3) The envelopes secreted by the oviduct, which may form a coating of nutritive material, or a protective shell, or both, as in the hen's egg, of which the nutritive white is secreted by the upper part, and the calcareous shell by the middle part of the oviduct.

In the bird and reptile families, the ova are fertilized before they leave the Graafian follicle. The eggs are fertilized very soon after insemination in both of these families. That the spermatozoa of birds are capable not only of penetrating a membrane, but of piercing both walls of a cell, is shown in Fig. 31, where the red blood cell is pierced by the spermatozoön, which fact establishes their ability to pierce a membrane beyond question.

(4) Covering Secreted by Accessory Glands.—This is seen in the slime in which the eggs of snails are em-

bedded, or in the tough capsules in which leeches lay their eggs.

The Cytoplasm.—The cytoplasm is the substance of the cell-body, which may be termed the ooplasm, and which is frequently spoken of as yolk, but does not include the nucleus, although the nucleus is situated within its stroma. The cytoplasm is composed of protoplasm, which forms a reticular structure, with the yolk-granules lying in its interstices. The granules in the centre of the ovum are matured first, which is shown by the granules growing less in size from the centre to the periphery, where they are ultimately lost. It is probable that the specific gravity of the granules is greater than that of the nucleus, and this is why it moves or migrates to the outer zone of the cytoplasm as the granules are advanced to maturity, or it may be that the taking of food by the nucleus from the peripheral border produces a current in which the reticular meshwork cannot form, and as the granules are formed from the centre the nucleus is gradually pushed by their formation to the peripheral zone, where it is usually found in the mature ovum.

The cytoplasm serves as a field in which nuclear division may take place. Segmentation cannot take place in a cell consisting only of a nucleus and centrosome, unless surrounded by a protoplasmic field. The spermatozoa are cells consisting only of the nucleus and a metamorphosed centrosome.

The Nucleus (Fig. 35, *n*).—The nucleus or germinal vesicle always lies in the protoplasmic zone, just outside of the granular mass. As the granular mass or deutoplasm extends, the nucleus is pushed toward the peri-

phery. Its form is spherical, surrounded by a distinct membrane; but during the growth of the egg it may become irregular or even amœboid. Its migration through the cytoplasm toward the source of food has been shown, in the case of insect eggs, by Korschelt. "The nucleus is generally regarded as the controlling centre of cell-activity, and is the primary factor in growth, development, and the transmission of specific qualities from cell to cell and so from one generation to another" (Wilson). The experiments of Seeliger, Morgan, and Drisch prove that fertilization of an entire enucleated ovum of one species by a spermatozoön of the other shows a very considerable range of variation; and while it was at first thought that the animals so produced would exhibit purely paternal characters, further experimenting by Seeliger ('94), Morgan ('95, 4), and Drisch ('98, 3) showed that this result was not entirely conclusive, since hybrid larvæ arising by the fertilization of an entire ovum of one species by a spermatozoön of the other present a very considerable range of variation; and while most such hybrids are intermediate in character between the two species, some individual may nearly approximate to the characters of the father or the mother (from Wilson). Here it is that the centrosome which is still in the cytoplasm of the ovum advances to activity in the cell division, thus maintaining and developing the maternal characteristics.

a. The nuclear membrane is a well-defined delicate wall surrounding the nucleus.

b. The nuclear reticulum forms an irregular branching network, consisting of two different constituents. The first of these, forming the general protoplasmic basis of

the nucleus, is known as linin. The second constituent, a deeply staining substance, is known as chromatin (Flemming). The chromatin is one of the essential structures in segmentation of the cell. It is not the active part of the cell, but the most essential part of the cell to be acted upon. The fact that the polar bodies are formed apparently for the sole purpose of eliminating all the superfluous chromatin, is indicative of its being a burden rather than an assistant to cell-division. A great or an excessive quantity of chromatin in the active formation of the nucleus will not hasten but slow down cell-division. The chromatin or chromosomes of a cell, while absolutely necessary for cell-division, is to be regarded as the burden, and not as the dynamic centre of cell-division.

The Nucleoli.—There are at least two different kinds of nucleoli. The first and most important is the true nucleolus or plasmosome, which is spherical in shape, is enclosed in a very delicate membrane, and is shown by staining to differ from chromatin. It is probable that this nucleolus serves in receiving and distributing nutriment to the various parts of the nucleus, in which case it should be situated in the nucleus next to the peripheral zone, or on the side from which the greatest part of the nutriment is received. The nucleoli of the second kind are different from those of the first in that they are not surrounded by an enveloping membrane, are more often irregular than spherical in shape, and agree in staining reaction with chromatin, and there is good reason to believe that they are merely small masses of chromatin in the resting state.

The Centrosome (Fig. 35, *c*).—The centrosome is a

minute particle, and is usually present in pairs. In the ovum they are always in the cytoplasm, lying near the nucleus or in an indentation in it. Van Beneden, Boveri, and many late writers regard the centrosome as a distinct and persistent cell-organ, which like the nucleus was handed on by division from one cell-generation to another. My discovery not only proves that it is a distinct and persistent cell-organ, but that through it the sex of all animals is controlled, and that the characteristics are either transmitted by it, or developed through the power of its presence. When only the nucleus and a very small centrosome are delivered to the cytoplasm of the ovum by the spermatozoön, a female is produced. In this case the aster is formed from the resting aster situated in the cytoplasm of the ovum. The chromatin of mammals, birds, fish, and reptiles entering into the production of females is identical in quantity with that of the male. A more powerful centrosome is necessary to produce the male in the above group of animals. This is furnished to the ovum by the body and the tail of the spermatozoön entering the cytoplasm of the cell. The large centrosome, or the material from which the masculine part of the aster is formed, is stored in the body and the tail of the spermatozoön. In *Heterokis*, *Lygacus*, and *Euschistus*, and the entire series of this species, the size and quality of the centrosome, or that part of the cell from which the aster is produced, are the same in power in both the male and the female. The difference in the zygote of the sea animals consists simply in the greater number of chromosomes in the female and at least one less in the male. The effect of this is

precisely the same as the addition of just a little larger centrosome to a given quantity of chromatin for the production of a male, and a little less for female-production. In the honey-bee, all the eggs without exception form two polar bodies, and the unfertilized egg invariably

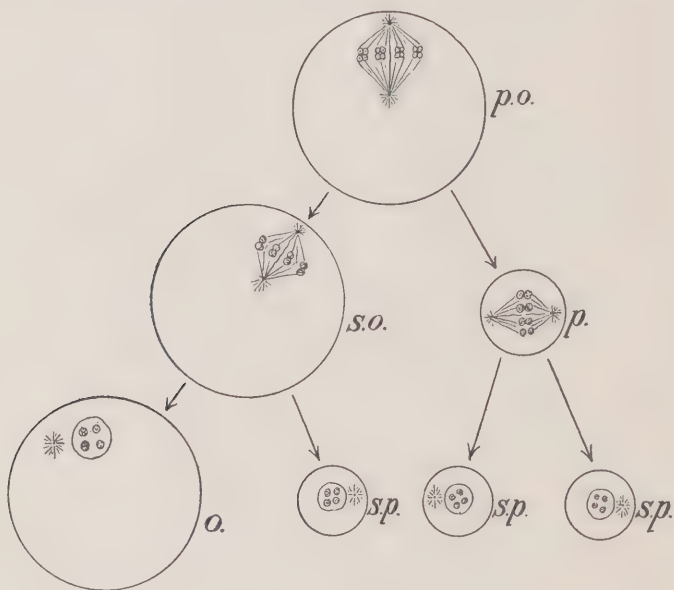


FIG. 36.—DIAGRAM SHOWING THE REDUCTION OF THE CHROMOSOMES DURING THE MATURATION OF THE OVUM.

p.o., Primary oöcyte or ovarian egg; *s.o.*, secondary oöcyte; *p.*, first polar body; *o.*, mature ovum; *s.p.*, secondary polar bodies.

develops into a male. In this case the burden (one-half of the number of chromosomes) has been eliminated. Yet the ovum still contains the same quantity of centrosome (or aster) forming substance. The centrosome acting upon a small number of chromosomes gives rise

to a more rapid cell-division, which produces the drone or male bee. If the queen bee has copulated and the ovum is fertilized, only the nucleus containing the chromosomes is added. The tail of the spermatozoön (the centrosome-forming substance) is left without, with the result of inevitable female-production.

Maturation of the Ovum.—"The term maturation is restricted by usage to the series of phenomena accompanying the expulsion of the polar globules which occurs

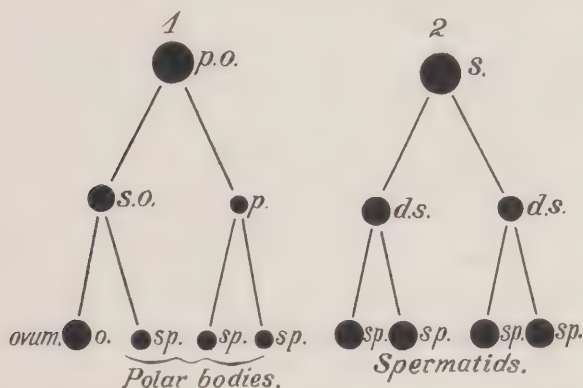


FIG. 37.—DIAGRAM SHOWING THE SIMILARITY OF THE MATURATION PHENOMENA TO THOSE OF SPERMATOGENESIS.

1, *p.o.*, Primary oöcyte or ovarian egg; *s.o.*, secondary oöcyte; *p.*, first polar body; *o.*, mature ovum; *s.p.*, secondary polar bodies. 2, *s.*, spermatocyte of the first order; *d.s.*, the daughter spermatocytes; *sp.*, spermatids.

after the cell has attained its full size, and just before or just after the separation of the ovum from the ovary " (Minot). I am of the opinion that maturation takes place upon relief of the pressure to which the ovum is subjected in the Graafian follicle, which may occur before its expulsion owing to the thinning of the tunica

albuginea with the consequent relief of pressure. A polar globule is a small, nucleated mass, consisting chiefly of chromatin and almost destitute of cytoplasm, extruded from a fully grown egg-cell. When an ovum is about to mature the nucleus moves to the surface, and contraction of the vitelline membrane occurs. The contraction of the vitellus is probably a constant phenomenon and it is effected by the expulsion of fluid from the protoplasm, so that a clear space separates the zona radiata and vitellus. After the formation of the second polar globule, the chromatin has been reduced to one-fourth of that which entered into the formation of the first polar spindle. In the formation of the second globule, the chromosomes are always reduced to one-half the number characteristic of the species to which the animal belongs.

CHAPTER VI.

MENSTRUATION.

Synonyms.—Menses; menstrual flow; menstrual flux; flow; catamenia. Women have various popular names for it, mostly metaphorical and conventional. These terms are used in reference to that phenomenon in the human species while the following terms are applied to the homologous condition in animals: Heat; rut; must; œstrum, etc.

By the term menstruation is meant the monthly hemorrhage which takes place in the uterus during the child-bearing period of the normal woman, except during pregnancy and lactation, when it is usually suspended. Menstruation is the only guide to the control of sex and for that reason each and every phase of the phenomenon should be thoroughly understood.

Puberty.—The first occurrence of menstruation with the concomitant changes marks the epoch of sexual maturity at which, in the female, impregnation becomes possible. The signs (as Parvin gives them) are: “The girl’s pelvis enlarges and her breasts notably increase in size as she enters this period of life; the one change indicates preparation for childbirth, the other provision for the nourishment of the newborn. The external genitals are developed, and hair grows upon the mons veneris and upon the labia majora; the circumference of the neck is greater, and the voice changes; the body

is fuller and more gracefully rounded; sharp, irregular, and angular outlines are replaced by symmetrical curves, and new beauty of form and of general expression is manifested—it is the springtime of female life, the bud unfolding into the flower. The girl passing into womanhood puts away childish things, turning from frivolous amusements, from toys and plays, or from rude sports in which she has found pleasure; she enters a new life, has new thoughts, desires, and emotions. Hitherto she has been living solely in and for the present; but now the future with its lights and shadows, its hopes and fears, makes a large part of her life. She is more sensitive and reserved, and manifests a modest dignity, giving and expecting respect; her individuality becomes more manifest, her sense of duty stronger, and her ambition greater.”

This remarkable transformation is the expression of important changes in the internal generative organs, especially in the ovaries, for if the latter be absent or undeveloped, the distinctive sexual characteristics fail. During infancy and childhood the ovaries slumbered while nature's forces were busy building up the individual, and it is only when this end has been in good degree attained that provision is made for the continuance of the race. The ovaries now awaken from their silent, inactive state, notably increase in size, and enter upon the discharge of their special function; they determine the sexual character, and for thirty years or more exercise a dominant influence upon the female organism. Though commonly designated as uterine appendages, in a true physiology the uterus ought to be regarded as their appendage. The functions of the ovaries are the matur-

ing of the ovum and the maturing and rupture of ovisacs, with the consequent escape of ovules which are thus offered for impregnation, which process is known as ovulation, and as it occurs independently of sexual congress, it is called spontaneous ovulation. The menstrual function is not generally established at once, but for the first few months there may be only premonitory symptoms of a vague and uncomfortable nature when there occurs a slight discharge of mucus, later a discharge of mucus slightly tinged with blood, and still later the regular menses are established.

Menstruation is usually established at about the time of puberty, and while in some childbearing women it is absent through life, in others it is absent until after pregnancy. This epoch is ushered in by the entrance of the ovary into active function. The universal law of periodicity now acts upon conditions prepared to respond. The determining conditions are—1. The energy of the sexual sense; 2. Latitude and mean temperature of the habitation; 3. Occupation and diet; 4. Race.

1. Sexual Energy.—In some individuals the tendency to early sexual maturity is well marked. The ovaries assume their function at a very early date; hair grows early; the system generally exhibits evidence of precocity; and the sexual proclivities are manifested. Susewind saw a child 27 months old, who had menstruated from the age of 12 months; she exhibited the molimen hemorrhagicum; her breasts and mons veneris were developed as in girls of 14 or 15. The following, reported by Mr. Dodd from Barnes' "Obstetrics," is therefore of special interest. On August 8, 1871, Mr. Dodd delivered F. M. of a female child. This child began to menstruate at

12 months, not very regularly at first, but varying from four to six weeks' intervals. The last two years (1878-79, 1880) the menstruation was every three weeks. The last appearance was on June 22, 1880, when she became pregnant. Mr. Dodd attended her in her labor on March 17, 1881. The child weighed 7 lbs. It died some time after in convulsions. The labor was not difficult. The hirsute growth on pubes and in axillæ was profuse; the breasts a week after labor were large and gorged with milk. The child was thus pregnant before she was 9 years old. This duration of her gestation may be estimated at 269 days. Ahlfeld reports the case of Anna Mummenthalen who menstruated from her second to her fifty-second year. In her eighth year she became pregnant, and gave birth to a child in her ninth year. Montanaier cites the case of a child less than six months old, very large and with well-developed breasts. D'Outrepont reports a birth in the ninth year of age without the establishment of menstruation.

In support of the fact that pregnancy can take place in complete absence of menstruation, Ahlfeld reports the case of a woman who had never menstruated, but who bore a child in her thirty-second year. He also reports the case of a woman who had had eight children, but who had never menstruated. Parvin reports a case in which menstruation began at the age of three years and a half, and continued regularly. Ploss has collected forty-five instances of precocious menstruation, the oldest of the subjects being in her eighth year. But in some of these girls there was disease of the ovaries, in others hydrocephalus, and in still others rickets; nevertheless, the majority of the children were

healthy. In some instances of precocious menstruation precocious maternity was observed. Robert Barnes reports several cases of premature menstruation in which exhaustion and death occurred, but this was not the rule. Kussmaul says precocious menstruation is sometimes the result of disease, especially of new growths in the ovary. Cases in which births occurred after the cessation of menstruation are also noted. Kennedy cites the case of a woman sixty-two years of age who gave birth to a child. This patient had, in all, borne twenty-two children. Menstruation had always been regular. La Mott reported a case in which a woman gave birth to a child seven years after the menopause. The time of cessation normally occurs about the forty-fifth year. The above cases are the most abnormal on record which have occurred in both England and the United States during the past century. Precocity in the human female attended by menstruation is undoubtedly due to an excessive quantity of blood supply to the ovaries. Should such a condition present itself in those under seven years I would unhesitatingly advise the ligation of the larger artery (the ovarian, or the ovarian branch of the uterine arteries), for the reason that modern surgery has advanced to such a degree that the danger attending such an operation could not be compared to the abominable condition from which the child must otherwise suffer. Amenorrhœa is present in such a small number of women that it is scarcely necessary to consider them. Menstruation is usually established after the first pregnancy, when the women can produce the desired sex. In the two cases of amenorrhœa among the records of one thousand families which I shall introduce later,

pregnancy followed immediately in each case, a boy and a girl having been born promptly nine months after marriage. While the sexes differ in these cases, this condition favors an excess of females. While pregnancy immediately followed insemination in both of these cases, such result is very unusual. Parvin gives the following: "Apathy of the genital sense is manifested by delayed menstruation in persons whose health is good. This delay may extend to four or five years, or even a longer time, beyond the period when menstruation usually begins; in some cases menstruation did not occur until after one or more pregnancies, but of course the probability of conception prior to the establishment of this function is very small." According to Villaret, Joan of Arc was "exempt from the tribute which women pay the moon"; and he suggests that this exemption was due to her high destiny. She was only twenty years old when she was executed, so that, admitting the fact of her amenorrhœa, it is possible that the establishment of her menstruation was simply delayed.

2. Latitude and mean Temperature of the Habitation.

—Barnes quotes the following: "Joulin divides the peoples subjected to his statistical analysis into three zones. The temperate zone, situated between lat. 33° and 54° north; the second, belonging to hot climates, between 33° and the equator; the third corresponds to the cold regions, and extends from lat. 54° to the pole. Menstruation sets in in the temperate latitudes toward the fifteenth year; in the hot regions about the twelfth year; and in the cold about the fifteenth or sixteenth; but great variations occur in each region, some of which are

explained by the other influences specified." And farther on he says that, generally speaking, heat promotes menstruation, cold retards it, and refers to some women who menstruate regularly, perhaps profusely, in India, and see scarcely anything in England. Others in England menstruate only in the summer. Edgar gives the following: "It is said that English girls in Calcutta menstruate no earlier than in England, although subjected to the same climatic influences as the Hindoos, one or two per cent of whom menstruate as early as the ninth year, while twenty-five per cent menstruate at twelve years of age. The children of the superior classes, being of a higher nervous organization, are apt to menstruate earlier. Their manner of life is more luxurious and mental stimulation is premature, as shown in the earlier period of menstruation. As to the influence of climate, it has no doubt been exaggerated, although the general rule holds that menstruation occurs somewhat earlier in the tropical than in the Arctic regions." Parvin says: "In temperate climates girls usually begin to menstruate when from thirteen to fourteen years old; in warm climates the function occurs earlier, in cold later." Raciborski states that a year's difference in puberty corresponds to a difference of eight or nine, sometimes of only four, degrees of latitude. His tables, including 25,952 observations, show that there is a difference of three years ten months and thirteen days between the time of the first menstruation of the girls living in Central Asia and that of those living in Lapland. Krieger gives as the two extremes, eighteen years in Swedish Lapland, and ten years each in Egypt and in Sierra Leone.

The fact that the girls from a temperate climate subjected to the heat of a tropical climate do not menstruate any earlier, and those from a hot tropical climate subjected to the cool temperate climate do not menstruate any later, is good proof that menstruation is not hastened by heat or delayed by cold; but that the variation of the first menstruation is due to the universal law which is found throughout the animal kingdom. Men or animals of short life are early to mate and propagate, while those of long life are late to mate and propagate.

As a general rule, it will be found that the longevity of those living in a hot climate is from four to six years shorter than that of those living in a cold or temperate climate. *The age at which menstruation begins depends upon the primordial vitality of the girl and not the temperature to which her body is subjected.*

3. Occupation and Diet.—The easier classes, who live luxuriously, usually menstruate early and freely, while those who live hard laborious lives menstruate less and later. Girls changing from country life and habits to those of a city, to work in sedentary occupations, housed in hot rooms, and subject to the promiscuous mixing of sexes, may menstruate sooner (Barnes, who refers to Stoltz, Brierre de Boismont, Leudet, Bernard, Faye, Mayer; Edgar, who refers to Clay, "Brit. Record of Obstet. Med.," vol. i., and Parvin).

4. Race.—The time of the first menstruation, as to age, varies in different races. Races of long life that are late in reaching puberty will begin to menstruate later than those of short life and early maturity or puberty. Otherwise the onset is the result of direct stimulation of the sexual organs by an increased flow of

blood to them, which may be superinduced by psychical or ocular impressions, or by congenitally large arteries to these organs. The Jewish race, which so strikingly maintains its individuality in all ages and places, and among all peoples, shows in regard to the first occurrence of menstruation but little differences of time, no matter what differences of latitude or climates are compared (Parvin, Barnes, etc.). The daughters of English residents in India do not menstruate as early as the native Hindoo girls (Parvin, Barnes). Parvin refers to the report given by Depaul: "Negresses born under the burning sky of Africa or of South America menstruate early, and those in Europe are equally precocious." A mother who menstruates early or late is liable to transmit this peculiarity to her daughters, independent of race (Parvin).

The phenomena constituting and attending menstruation are constitutional and local.

(1) The constitutional phenomena consist of pain in various parts of the body, hot flashes, chilliness, and hysterical symptoms. There are often considerable changes in the nutritive processes and the excretion of urea by the kidneys is lessened, dark circles appear under the eyes, the breasts swell and become painful. The reflex nervous system is usually at its maximum point of irritability and there is often depression with drowsiness, a sense of fulness and oppression is felt in the head and a feeling of general discomfort, weariness, and a marked distaste for active exercise.

(2) The local phenomena are those of hyperæmia and then congestion of the female sexual organs. The ovaries, uterus, Fallopian tubes, broad ligaments, vagina,

vulva, and mammary glands, all participate more or less in the hyperæmic condition which passes into congestion and sometimes inflammation of the parts. The ovaries first become congested, then the uterus becomes much congested, the cervix softens and is of a bluish color, with relaxation of the external and the internal os. The uterine mucous membrane is also swollen, congested, and raised into folds which give the surface an irregular appearance; abundant secretion pours from the glands, and, at least in some cases, the epithelium desquamates, and the capillaries losing their support, their walls undergo fatty degeneration, burst, and discharge the blood. The tubes are also congested and thickened, and blood sometimes escapes into them. The vagina becomes darker in color, glandular secretion is abundant, and the temperature is slightly elevated, often by 1° F. The whole vulva is swollen and tense, and pruritus may occur. The following is an excellent observation made by George Harley, as given by Barnes: "A married woman, æt. 23, drowned herself when menstruation was impending. The uterus was congested and enlarged to about one-half more than its usual size. On section the uterine tissue was rosy, and the open mouths of its blood-vessels were distinctly visible. The vagina was somewhat congested externally, but of the normal color internally. The mouth of the womb was filled with a white tenacious mucus, while the mucous membrane of the interior was hypertrophied throughout its whole extent, of a pink color, which gradually increased in depth toward the fundus, at which it attained a dark livid color, and was covered with a quantity of blood. The blood was in greatest quantity at the mouths of the

Fallopian tubes, but neither the congested nor the hemorrhagic state of the mucous membrane extended beyond the openings of the tubes. Their interior was quite white and clean at the uterine extremity, but highly congested and filled with a milky fluid toward the fimbriated end. This mucous secretion was loaded with ciliated and other epithelium. The ovaries were enlarged, especially the left one, which contained a Graafian vesicle, 0.75 mm. in diameter, ready to burst, and which actually burst while being handled. The vesicle contained a clear straw-colored serum, with a few flakes of the membrana granulosa floating in it. On the interior of the vesicle were numerous vessels, which gave to it a highly congested appearance."

Howell gives the following: "Menstruation is a phenomenon of the uterus. The lining mucous membrane, the endometrium, in the period of four or five days preceding the flow, becomes rapidly thicker and its superficial layers are congested with blood, and indeed in places small collections of blood may be noticed. Opinions differ very much as to the change undergone by this thickened membrane during the flow. According to some authors, most of the membrane is thrown off and the blood escapes from the denuded surface mixed with pieces of the membrane. According to others, no material destruction of the membrane occurs, the blood that escapes being due to small capillary extravasations or perhaps mainly to a process of diapedesis. It would seem that the amount of destruction of the endometrium must be subject to individual variations. After the cessation of the flow the mucous membrane is rapidly repaired by regenerative changes in the tissue; the

surface epithelium, if denuded, is replaced by proliferation of the cells lining the uterine glands and the thickened, œdematous condition of the membrane rapidly subsides during a period of six or seven days. While the escape of blood takes place only from the surface of the uterus, the other reproductive organs—the ovary, the Fallopian tubes, and even the external genital organs—share to some extent in the vascular congestion exhibited by the uterus during the period preceding the menstrual flow. The mucous membrane of the uterus may be said to exhibit a constantly recurring menstrual cycle which falls into four periods:

“(1) Period of growth in the few (5) days preceding menstruation, characterized by a rapid increase in the stroma, blood-vessels, epithelium, etc., of the membrane.

“(2) The menstruation or period of degeneration (4 days), during which the capillary hemorrhage takes place and the epithelium suffers degenerative changes and is cast off more or less.

“(3) The period of regeneration (7 days), during which the mucous membrane returns to its normal size.

“(4) The period of rest (12 days), during which the endometrium remains in a quiescent condition.”

The above division of the menstrual cycle into definite periods was undoubtedly made from the author's personal observation of very many cases. The period of menstruation and regeneration corresponds to the time of uncleanness of the woman in the Mosaic law, during which time insemination is forbidden. While Howell made his observations from those who reside in a temperate climate between 35° and 45° north latitude, the Mosaic law was given to those who were acclimated to

the region south of 20° north latitude. As the conditions peculiar to menstruation are handed down to the offspring, the observance of the law of Moses was still necessary, although his people had been transplanted to a more temperate climate; for in the warmer region urethritis follows the act of insemination during this period.

After carefully studying this problem, it seems logical to regard the period of rest as the physiological period for the reception of the fertilized ovum, and no doubt nature has decreed that it should take place during this period.

Relation between Menstruation and Ovulation.—

Nature has designed that ovulation should take place just prior to, or during, the period of rest in the uterus. At this period the cilia of the epithelium are more sensitive, more active, and more powerful. Their movements create a current in the mucous secretion both in the uterus and in the Fallopian tubes. This current carries the ovum from the fimbriated extremity of the Fallopian tube to the uterine cavity, and the mucous secretion from the uterus to the vagina. The truth of this statement has been proved several years ago by Hofmeier, who showed that the ciliary motion was all in the same direction, toward the outlet of the uterus. This current, set up by the ciliated epithelium, prevents the fertilization of the ovum by the deformed and decrepit spermatozoa. The more rapid the current, the more rapidly the spermatozoa would have to move to make search for the ovum and maintain their position. In this most peculiar mechanism, we have the greatest safeguard to the animal kingdom, for it insures fertiliza-

tion by active spermatozoa, and goes far to keep the tubes and the uterine cavity in an aseptic condition. The beginning of menstruation is the announcement of the rupture of the wall proper of the Graafian follicle, formed from the stroma of the ovary; this probably allows the extrusion of part of the follicular secretion into the stroma of the ovary, which produces inflammation of the gland and establishes menstruation. On account of its delicate structure, one is led to anticipate a rupture of the inner tunics of the follicle and the escape of at least part of its contents, on rupture of the capsule derived from the ovarian stroma. The surface of the ovaries of the old woman is covered with cicatricial tissue, and when the tunics derived from the stroma of the ovary rupture, the follicle is prevented from migrating to the surface of the ovary by the tough scar tissue, and in this case the contents of the follicle are extruded into the stroma of the ovary. The follicular secretion is gradually absorbed, which gives rise to dystocia and menorrhagia in the older woman.

The time required for the maturation of a Graafian follicle and its ovum during sexual life depends upon the individual, her general health, and her environment. A normal woman, under normal conditions, who is not subjected to anything unusual, will mature the Graafian follicle in the time given under the maternal secondary laws (page 206). At the age of twenty-four the human female will normally mature the Graafian follicle midway between the last day of one menstrual flow and the first day of the anticipated menstruation. The development of anything unusual in or about the woman may cause either delay or premature rupture of the Graafian follicle.

Premature rupture or rupture after maturity may be caused by coition, or by a great desire for it, or by psychical or ocular impressions which produce a flow of blood to the sexual organs. Constipation with resultant straining at stool, difficult micturition, coughing, singultus, lifting, or any physical exertion which would cause a forced contraction of the abdominal muscles; retention of a large quantity of urine causing distention of the bladder, or the retention of fecal matter causing distention of the sigmoid flexure of the colon, either or both of which latter conditions are liable to produce direct or indirect pressure against the ovary; increased blood-pressure produced by a cold bath, or cold acting on the body and forcing the blood from the peripheral blood-vessels to the internal organs; the taking of an unusual quantity of easily assimilable food, which would increase the blood-pressure and augment the contents of the abdominal cavity—either one or several of these acting together may give such an impetus as would rupture a Graafian follicle near its maturity. Ergot, digitalis, etc., would probably produce the same result.

The fact that menstruation is the announcement that a Graafian follicle has developed to maturity is beautifully demonstrated in the bitch, in the elephant, and in some cows, in which œstrum appears only once in from three to six months. Upon insemination the female dog delivers her young in sixty-three days; the elephant delivers her young in eighteen to twenty-two months, and the cow in nine months. I consider this positive proof that the ovum from the Graafian follicle which set up the menstruation is the ovum fertilized in the human species, and not the ovum from the first missed

menstruation. Or, in other words, the ovum extruded from the Graafian follicle which set up the menstruation is the only ovum found in the Fallopian tubes or uterus until after a succeeding menstruation, assuming the woman to be in a normal condition. In all these cases, it is impossible for the ovum from an anticipated œstrum to be present at this period. In the female dog, the number of the young can be regulated by preventing copulation until the lapse of twelve or fourteen days after the beginning of the œstrum, since by so doing only one or two pups are generally born; but, if copulation takes place immediately or soon after the beginning of œstrum, from five to eight pups are usually produced. This demonstrates beyond question that the ova which set up the œstrum are the ones fertilized; furthermore, that not all the Graafian follicles come to maturity in the same female dog at the same time during the same œstrum; and finally that only some of the ova may be fertilized, while the others from the Graafian follicles which ruptured earliest escape. But if copulation be delayed, one could not hope to produce female pups, inasmuch as the spermatozoa would not have to wait for the ova and fertilization would take place almost immediately. The spermatozoa with large heads, excepting those described on page 69, are more active than those with small heads or nuclei; accordingly they proceed rapidly, keep in advance of the crowd in search for the ova, and pass through mucous secretions flowing in a swift current; while, on the other hand, the old, slower, small-headed female-producing spermatozoa are left behind in the race. In some exceptional cases a Graafian follicle which set up menstruation may not be ruptured

until after a succeeding catamenia, and in such a condition it would probably rupture during or soon after the flow.

According to Oldham, as quoted by Barnes, the ovaries enlarge for about four days, remain stationary for about three days, and then gradually subside. It has also been ascertained that the enlargement commences as a rule shortly before the menstrual period, that it attains its maximum about the time of the flow, and that it subsides after the menstrual hemorrhage (Robert Barnes and Fancourt Barnes). "Both enlargement and subsidence are periodically recurring processes, and their periods correspond so closely that ovulation and menstruation occur simultaneously. However, although this may be, and probably is, the rule, yet it is far from being an invariable one" (Barnes).

The human ovary is covered by short columnar epithelium derived from the peritoneum, inside of which are the Graafian follicles containing the ova. Each Graafian follicle contains an ovum and an epithelial envelope, and in the smallest follicles the ovum is small, the epithelial envelope consisting of a single layer of small cells, which may be flattened. In the larger follicles the epithelial cells are in two layers, and these are columnar in shape. In the largest Graafian follicles, each of these layers is formed of several strata of cells, and fluid may collect between these layers at any point. The discus proligerus immediately surrounds the ovum and forms the internal layer, while the outer layer lines the cavity of the follicle and is known as the *membrana granulosa*. The Graafian follicle gradually becomes larger and the fluid increases in quantity until it produces rupture of the *theca folliculi*; this is probably followed

by the escape of a small quantity of the follicular secretion through the inner tunic out into the stroma of the ovary, where it is absorbed. It is very probable that the absorption of this secretion produces inflammation of the ovary and the establishment of menstruation. The size of the Graafian follicle still increases until the tunica albuginea finally yields. The migration of the follicle through the tunica albuginea undoubtedly consumes from ten days to three weeks. The ovum, having passed into the medullary part of the ovary from its surface, carries before it a certain quantity of stroma tissue, which is later reinforced with blood-vessels and prevents the rupture of the theca folliculi on its medullary surface. Therefore rupture of the theca folliculi takes place at the stigma, the point of least resistance, which is always nearest the place from whence the Graafian follicle entered the ovary. When rupture of the theca folliculi occurs, a part of the follicular secretion is extruded into the stroma of the ovary from the point of rupture, and as soon as the follicle approaches and comes into contact with the tunica albuginea, further escape of the secretion is cut off by the support rendered the tunica granulosa by its contact with the albuginea. Now that the follicle is in contact with the tunica albuginea it is carried before it as the follicle increases in size, and accordingly the tunica albuginea diminishes in thickness until the follicle is at last ruptured. As soon as the escape of the follicular secretion is cut off by its contact with the tunica albuginea, inflammation of the ovary subsides, and the normal condition is resumed. If, however, the follicle on its migration to the surface of the ovary comes into contact

with dense, tough scar tissue the escape of the follicular secretion may continue and progress of the follicle to the surface of the ovary be prevented, in which case it would undergo absorption and degeneration. As Schäfer says, "Some of the Graafian follicles do not burst, but after attaining a certain stage of maturity undergo a process of retrograde metamorphosis and eventually disappear." The latter condition would occur only occasionally in the young female, though it is probable that it frequently occurs in older women and gives rise to dysmenorrhœa often met with in them. We can now readily understand why dysmenorrhœa may be attended by great variation in the maturation of the Graafian follicles. The point which I wish to make clear is the fact that rupture of the Graafian follicle does not normally occur until from five to sixteen days after the menstrual flow, and that, when the Graafian follicle is ruptured, the ovum is normally propelled into the uterine cavity in six or eight hours. I furthermore state that the ovum does not usually remain in the Fallopian tube longer than from three to six hours. The time required for the ovum to reach the Fallopian tube after its extrusion from the Graafian follicle will always be problematical. It will vary in the same individual, and there is no way to prevent it except by gravitation (see page 46). It has been stated that "in order to reach the uterus the ovum has to pass through the whole length of the Fallopian tube, that this passage probably takes at least eight days before it is completed, and that fertilization takes place during the passage of the ovum through the Fallopian tube" (Barnes). If fertilization of the ovum generally occurred in the Fallopian tube,

and it took eight days for the ovum to make its passage through it, then tubal pregnancy would be rather frequent. Of course, it is not known just when maturation of the ovum is accomplished, but it is not necessary for the ovum to pass through the Fallopian tube and to reach the uterine cavity before fertilization takes place; if it were, such a thing as extrauterine pregnancy would be unknown. It is most likely that the relief of the general and uniform pressure on its extrusion from the Graafian follicle is soon followed by the maturation process or the formation of the polar bodies in the fully developed ovum. We should anticipate a delay in the formation of the polar bodies in undeveloped ova, when removed prematurely from the follicle. When maturation of the ovum has been accomplished, cell division is ordinarily resumed immediately upon fertilization; that is, under favorable conditions, which are always present in mammals. As soon as cell division begins, there is a general tendency on the part of the ovum to take up the more fluid constituents of the zona pellucida and of its immediate investment. The more solid tenacious constituents of the mucus surrounding the ovum are thus left without, and soon the cilia are powerless to move it. The cilia adhere to this tenacious and rapidly dwindling envelope of the ovum; and the latter, unless forced away by something more powerful than the cilia, remains in its present location. At this juncture, however, the peristaltic motion of the Fallopian tube may be set up and the onward movement resumed until the ovum shall have been forced into the uterine cavity. Many of the more recent authors concur in this opinion and give statistics which show that the extrusion of the ovum

from its Graafian follicle does not take place in very many cases until several days after the cessation of menstruation.

A Graafian follicle is not mature until it can be ruptured by orgasm in the female. As a rule, the maturity of a Graafian follicle is not complete until from seven to fourteen days after the last day of the menstrual flow. In those women whose menstruation is irregular and delayed from thirty-five to sixty days or longer, it is probable that the Graafian follicle does not mature until from ten to sixteen days after the last day of the menstrual flow. Normal menstruation is sometimes succeeded by a second blood-flow within a day or two after the cessation of the normal menstrual flow. This second flow of blood is probably due to the rapid advancement to maturity of another Graafian follicle. In all these cases there are two Graafian follicles and their ova to be considered in sex control. When it is desirable to produce a male child in these cases, the date for insemination must be calculated from the last day of the last flow, and to compensate for the excessive loss of blood, add two or three days to this date. The loss of blood delays the maturation of the Graafian follicle, and due time must be allowed for this.

The presence of a mature Graafian follicle in the ovary serves to create a desire for cohabitation on the part of the female, for her state is analogous to that of the male when the vesiculæ seminales are filled with semen. The assertion made by some women, and accepted by a few obstetricians, that a peculiarly pleasurable sensation attends fruitful intercourse, as given by Parvin, is undoubtedly to be explained by the rupture of a Graafian

follicle during orgasm, which relieves the female of further desire for intercourse, and the chance for pregnancy is at its maximum when rupture of a Graafian follicle takes place during cohabitation.

CHAPTER VII.

THE PROCESS OF INSEMINATION.

By insemination is meant the deposition of the seminal fluid within the genital tract of the female during the sexual union. Before conception can take place there must be a union and fusion of a spermatozoön with an ovum. When this occurs, the woman conceives and enters upon the period of pregnancy or gestation. When the semen is deposited in the genital tract the spermatozoa make their way to the ovum by virtue of their inherent power of locomotion. Many theories have been advanced to explain the method by which the spermatozoa reach the uterus, one of the oldest being that of Johann Müller, who thought that the semen was forced in by the piston-like action of the penis. Litzmann, Wernicke, and Beck advocated the aspiration theory, according to which the hood-like layer of the uterus contracts, forcing the cervix down into the lake of spermatic fluid; then, relaxation following, the semen is aspirated into the canal. Kristeller's idea was that the cervical canal was filled with a plug of mucus from the cervical glands; just as in the above theory, the uterus, contracting, pushes the mucous plug down into the semen, then relaxing, brings back the fertilizing fluid. Marion Sims' view has been received with the greatest favor. It is that the semen forms a lake in the posterior cul-de-sac, and, the cervix dipping into it, the fluid passes up the uterus.

Nature has provided that a rigid contraction of the uterus shall take place at the moment of the female orgasm, squeezing out every drop of the old viscid, thick, and semisolid mucus. On relaxation of the uterus from the orgasm the uterine walls slowly refill with blood as in the normal condition; they do not become engorged with blood as they were during the sexual union prior to orgasm. The uterine cavity is refilled with the mucous secretion from the Fallopian tubes, and the similar fluid from the mucous membrane lining its cavity. Thus the uterine cavity contains a fresh, thin, limpid secretion, in which the spermatozoa can move freely and actively. No part of the ejected mucous secretion from the uterus or the semen is drawn back into the uterine cavity on relaxation of the uterus. The spermatozoa propel themselves through this fresh, thin, limpid fluid, but can make no headway through the old, thick, viscid secretion. The sexual union produces an engorged condition of the blood-vessels of the vagina, uterus, Fallopian tubes, and ovaries, and the congestion causes a copious flow of fresh thin mucus from all the mucous glands in these organs. Spermatozoa are repelled by thick tenacious mucus, for as soon as they attempt to make their way through it they become fixed. After ejaculation of the semen into the vagina the spermatozoa pass out of the seminal fluid into the fresh mucous secretion and make their way unaided to the ovule. "The capacity of the uterine cavity in the nulliparous is from two to three cubic centimetres, or from thirty-two to forty-nine minims; in the parous three to five cubic centimetres, or forty-nine minims to one drachm twenty-one minims" (Parvin).

When we consider the small capacity of the uterine cavity, we can readily understand why no part of the ejected fluid nor the semen is aspirated into the canal on relaxation, inasmuch as the "anterior and posterior walls are normally in contact, or else separated by only a thin layer of mucus" (Parvin).

A proof of the truth of Marion Sims' theory is said to be furnished by the great infrequency of pregnancy in cases in which uteri, after operation, cannot dip into the spermatic fluid. Operations, however, usually leave scar tissue, and where there is cicatricial tissue there is an absence of glands and ciliated cells, therefore when the mucous secretion becomes lodged on scars, it remains more or less fixed and becomes very viscid, rendering the passage of the spermatozoa through it impossible. If the scar tissue encircles the os uteri, we can readily understand why it is almost impossible for the spermatozoa to pass it. Moreover, in case of extensive scar tissue at the mouth of the uterus, the mucus adhering to it prevents the uterus from freeing itself from the thick, viscid mucus which is ordinarily cast out during orgasm. There is no way, then, for the spermatozoa to avoid this thick viscid mucous secretion and to make their passage to the Fallopian tubes. The viscid mucus adheres tenaciously to the scar tissue which encircles the uterine canal and the orifice is corked with the same secretion, which has just been partially ejected from the uterus. When the female fails to reach orgasm, the old, thick, viscid mucous secretion remains in the uterine cavity and renders it difficult for the spermatozoa to make their way to the Fallopian tubes. The delay consumes the nutrition stored in the nuclei of the spermatozoa, the heads are

reduced in size and consequently rendered female-producing. Thus we understand how the tendency to female-production is augmented by failure of orgasm in the female during sexual union.

CHAPTER VIII.

THE CELLULAR BASIS OF THE DETERMINATION OF SEX IN THE HUMAN SPECIES.

Primary Law.—1st. The production of a male.

2d. The production of a female.

1st. The production of a male from the spermatozoön and ovum. When the sex-membrane covers less than one-half of the nucleus (Fig. 16), that membrane does not come into contact or clash with the vitelline membrane when the spermatozoön enters the cytoplasm of the ovum for the reason that it is posterior to the greatest circumference or diameter of the nucleus. The nucleus, by making a larger opening through the vitelline membrane into the cytoplasm of the ovum, prevents the sex-membrane from coming into contact or clashing with any obstruction. The nucleus of an ultra active spermatozoön passes through the vitelline membrane, carrying with it both body and tail regardless of the sex-membrane covering more than its posterior half. In any event the nucleus, the body, and the tail all enter into the cytoplasm of the ovum and a male is produced.

2d. The production of a female from the spermatozoön and ovum. When the sex-membrane covers more than one-half of the nucleus (Fig. 17), it comes into contact and clashes with the vitelline membrane. Even if the membrane is but partially stripped off the nucleus, a small quantity of the cytoplasm of the ovum flows in be-

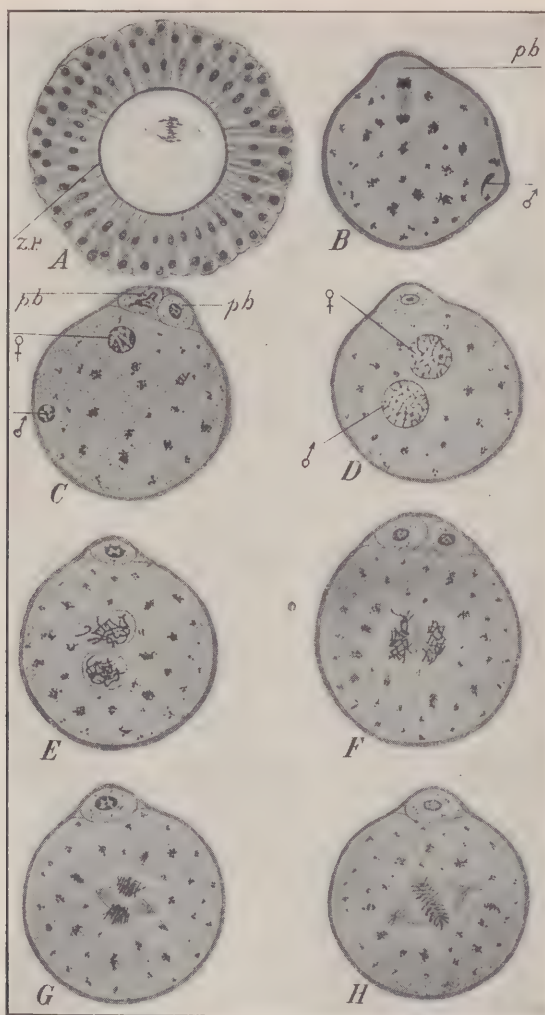


FIG. 38.—THE PRODUCTION OF A MALE RAT ZYGOTE, AS WITNESSED BY SOBOTTA.
(Description on opposite page.)

tween the sex-membrane and the nucleus. Here the cytoplasm comes into contact with the two or three small filaments which pass from the end-knobs of the centro-



FIG. 39.—THE PRODUCTION OF A FEMALE BAT ZYGOTE, AS WITNESSED BY VANDER STRICT.

(Slightly modified.)

The development of the sperm-nucleus from the head of the spermatozoon is very evident in this case, because the rest of the spermatozoon happens not to have been thrown off.

some in the body to the inner structure or smaller centrosome in the nucleus, liquefying them almost instantly,

FIG. 38—A, Maturation of the ovarian egg still partially surrounded by the follicle-cells and the membrane (*s.p.*, zona pellucida); the polar spindle-formed. B, Ovum immediately after fertilization (sperm-nucleus at ♂). C, After the first stage figured it is impossible to determine which of the two nuclei represents the male or the female pronucleus. ♀, Female pronucleus; ♂, male pronucleus; *p.b.* B and *p.b.* C, polar globules. D, Germ-nuclei approaching, of 'equal size. E, The chromosomes forming. F, The small cleavage-spindle in the centre; on either side the paternal and maternal groups of chromosomes. G and H, Last stages of nuclear cleavage. (Sobotta.)

when the body and the nucleus become disengaged. In consequence the body, the sex-membrane, and the tail are left outside the cytoplasm. The vitelline membrane is a very elastic membrane, and when the nucleus pushes through it, the latter is hugged so tightly that the sex-membrane is stripped off during the passage. When the body of the spermatozoön fails to pass into the cytoplasm of the ovum a female is produced.

Proof of the Above Statement.—This is the only conceivable method by which nature could draw a sharp line of demarcation, and one perfect in its working in the spermatozoa of the vertebrate animals. To understand this, is to understand why there are not more true hermaphrodites than the few on record. We can see that a half-way position is a thing almost impossible. The perfection of this method of sex determination is demonstrated and proved by the whole animal kingdom.

The next best proof of this biological law is furnished by several human eye witnesses of its occurrence. Sobotta, who was probably the first person to witness the production of a male rat, gives the following: "A spermatozoön makes its way through the vitelline membrane, becomes embedded in the cytoplasm of the ovum, and its tail is quickly absorbed by the cytoplasm while its nucleus and probably the middle piece persist as distinct structures" (Fig. 38). The production of the female has often been witnessed. One of the best illustrations, which is that of a bat, is given by Van der Strict (Fig. 39). The development of the sperm-nucleus from the head of the spermatozoön is very evident in this case, because the rest of the spermatozoön

is still on the outside and happened not to have been thrown off.

The above citations furnish what I consider absolute proof of this great law, and how it can be construed otherwise is more than one could comprehend.

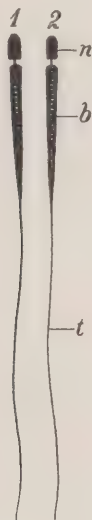


FIG. 40.—SPERMATOOA OF BAT.
(*Vesperugo*.)



FIG. 41.—SPERMATOOA OF RAJA
(Anterior Part).

FIG. 40.—1, Male-producing spermatozoön; 2, female-producing spermatozoön; *n*, nucleus; *b*, body; *t*, tail.

FIG. 41.—1, Male-producing spermatozoön; 2, female-producing spermatozoön; *a*, acrosome; *n*, nucleus; *b*, body; *ep*, end-piece.

The point next to be considered is, Is this a general law and are the spermatozoa anatomically so shaped that the result would be the same in all animals as well as in man? An affirmative answer can be given in the case of the following: Sturgeon and pike (cuts by Wilson from Ballowitz.) Both of these fishes could be

governed by this law; for in the case of the sturgeon the nucleus is shown to be smaller than the middle-piece, in which instance a female would be produced. As soon as the nucleus made its way through the vitelline membrane the middle piece, since it is larger than the nucleus, would clash with that membrane, so that it would be pushed back from the nucleus and expose the small filaments connecting the body to the head, while at the same time the cytoplasm of the ovum would flow in between the nucleus and the middle piece, the filaments would be immediately liquefied and separate the nucleus from the middle piece. In the case of the pike, in which the nucleus shown is larger than the middle piece, a male would be produced (Fig. 42, 1).* In the Raja (Fig. 41), the insect (*Calathus*) (Fig. 44), the bullfinch (Fig. 43), the bat (Fig. 40), the nucleus and the middle piece are so shaped that the introduction of the nucleus may take place very readily without the middle piece, as has already been explained (Fig. 43, B 2).

The fact that only one sex comes from an egg or ovum is further proof of this law. "In man twins may be born and these twins may be of two kinds. First, those that are developed from two different eggs, each of which has its own chorion and develops its own placenta. This kind may be designated as false twins, and in the matter of sex they may be male and female, or both male, or both female. The matter varies as in the statistics of births in general. In the other group, however, of true twins or identical twins, the two embryos are developed

* It is probable that the spermatozoa of the fish family are in a general way shaped anatomically like those just described, and would be subject to the same physiological law of fertilization.

from a single ovum and are included in a single chorion. In such cases the sex of the twins is always the same, they are both boys or both girls" (Howell). On this point Montgomery says: "We come now to the inquiry of what processes determine that an egg shall develop into a male

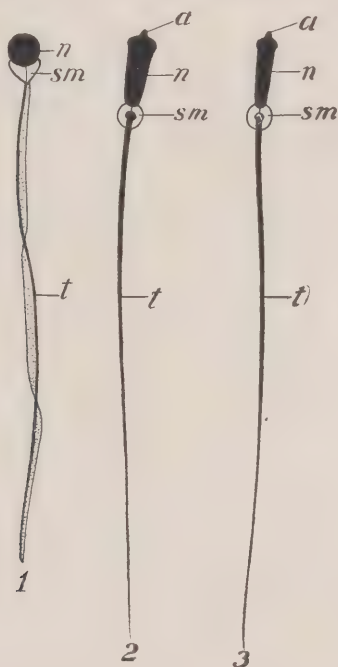


FIG. 42.—SPERMATOOA OF FISH.

1, Pike, male-producing spermatozoön; 2, sturgeon, male-producing spermatozoön; 3, female-producing spermatozoön of the sturgeon; *a*, acrosome; *n*, nucleus; *s.m.*, sex-membrane; *t*, tail.

or a female individual. And just here it is to be noted that the sex of the individual is probably determined not later than the stage of fertilization of the egg. This is to say, despite the numerous experiments made in the

hope of securing positive results, it has not yet been possible to alter the sex ratio by external influence acting after the one-cell stage of the organism. The nearest approach to securing this end has been reached by Shull (1910), who found that by altering external conditions,

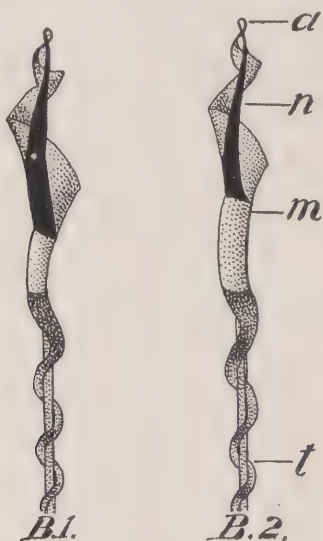


FIG. 43.—SPERMATOOA OF BULLFINCH.

B.1. Male-producing spermatozoön; *B.2.* female-producing spermatozoön; *a*, acrosome; *n*, nucleus; *m*, the body; *t*, part of the tail.

namely, composition of the water, the relative numbers of male-producing and female-producing individuals can be changed in Rotatoria. The main result reached after much experimentation and discussion is that the sex of the individual is probably established not later than the stage of fertilization; and there is still no body of evidence that the sex state so established can be changed by in-

fluences acting during a later stage. In this connection may be noted the interesting cases of polyembryony, where several embryos come from the same egg. This has long been known for trematodes and cestodes, more recently for some parasitic wasps (Marshall, 1904, Sil-



FIG. 44.—SPERMATOOA OF INSECT (*Calathus*).

A.1, Female-producing spermatozoön; A.2, male-producing spermatozoön; *n*, nucleus; *sm*, sex-membrane; *t*, part of the tail.

vestri, 1906), and has been made known within the year for the armadillo by Newman and Patterson. In these cases all the embryos from one egg are of the same sex, which shows that the sex feature must be stamped in the organism very early."

In the lower forms of animal life, as the hermaphrodite,

the line of demarcation between the nucleus and the middle piece of the spermatozoa is not constructed anatomically so that the introduction of the nucleus could take place unaccompanied by the middle piece. For this reason, they have not advanced to the higher form of sexual reproduction.

In heteroparthenogenesis both sexes are produced from unfertilized eggs as in Aphides, Rotatoria, and Daphnids. The Aphides (plant-lice), while living under favorable conditions of nutrition, produce only females the eggs of which develop parthenogenetically. In the autumn, under less favorable conditions, males as well as females are produced; and in the favorable environment of a greenhouse the production of females alone may continue for years. In the Hydatina, the sex is determined at a very early period, before the egg is laid; the eggs being of two sizes, of which the smaller give rise only to males, and the larger only to females. Here again the well-fed females produced a preponderance of female offspring, and vice versa. The eggs laid during the favorable environment, when the females are well fed, are large, female-producing parthenogenetic eggs. It is during this period that the nurse cells of the eggs in the ovaries are able to furnish to the ovum all nutriment necessary for its production, and in abundance, which is demonstrated by the size of the eggs. In this event the quantity of the fertilizing element (found in the middle piece of the spermatozoa) is insufficient to produce male offspring. In a less favorable environment, when the food becomes scarce, the nurse cells are unable to take up from the circulation sufficient nutrition for the production of eggs, in which event the nurse cells themselves are engulfed

and taken into the cytoplasm of the ova, when their lives are sacrificed for the production of ova. In this way the ovum receives from the nurse-cell body sufficient of the fertilizing element to produce a male. That the bodies of the nurse cells are taken into the cytoplasm of the ova and the life of the nurse cells sacrificed for the production of ova has been proved and is beautifully shown in the *Hydromedusa Cladonema*, in an observation published by Weismann.

In homoparthenogenesis only one sex is produced from unfertilized eggs, which may be arrhenotoka or the formation of males, as in the honey bee, or thelytoka or the formation of females alone, as in the moths. When the nurse cell is engulfed by the ovum it would probably contain more of the material entering into the formation of the aster, which stimulates cell-division and the formation of the second polar body, thus eliminating its burdensome quantity of chromosomes and at the same time the dynamic power is not lessened. Formation of the second polar body in all unfertilized parthenogenetic eggs is followed by the production of males. In the formation of the second polar body one-half of the chromosomes characteristic of the female are eliminated; if this is not fertilized a male is produced. Male-production is caused by the reduction of the chromosomes in the zygote. This eliminates the chromatin which is the burden that slows down cell-division, giving rise to female-production. If, in the event the egg is fertilized after the formation of the second polar body, the chromosomes (the burden) are restored, the result is female-production. In fertilization of the parthenogenetic eggs the nucleus only is added. Thus the aster-forming substance (the centro-

some) is the same in quantity, while the chromosomes vary; there being less in male-production. In the vertebrate the chromatin is constant in quantity, while the centrosome (aster-forming substance) varies, there being a larger centrosome in the male-production.

In W. E. Castle's contribution from the zoological laboratory of the museum of comparative zoology at Harvard College he says: "With a single exception to be discussed presently, we know that in uninterrupted parthenogenetic reproduction, as it occurs, for example, in the *Daphniæ* and *Rotifera* at certain seasons of the year, the parthenogenetic egg forms only one polar cell, and the animal developing from such an egg is invariably female, the male character being recessive. In other words, the daughter produced by parthenogenesis is exactly like the mother. No segregation of sex-characters has taken place in her development. That the male character is still present in the agamic female is known from the fact that such a female retains the capacity to produce males under appropriate external conditions.

"At the return to sexual reproduction, the parthenogenetic mother produces eggs which form a second polar cell, and from such eggs (if unfertilized) only males develop. It is clear, then, that in the second maturation division the female character has been eliminated from the egg, for were it still present there, it must from its nature dominate.

"In the honey-bee, all the eggs, without exception, form two polar bodies, and the unfertilized egg invariably develops into a male. Accordingly a queen bee which has not copulated can produce only male offspring. But one which has copulated produces both male and female

offspring, the former, however, only from unfertilized eggs, the latter always from fertilized eggs.

"In parthenogenetic rotifera and crustacea, under favorable external conditions, the egg develops straightway after the formation of a single polar cell, usually while still within the body of the mother, and without awaiting the occurrence of a second maturation division. No segregation of sex characters has yet occurred within the egg, which develops, without the necessity of fertilization, into an agamic female like the mother. If, however, external conditions are unfavorable, the egg will not proceed to develop until it has undergone a second maturation division. The egg is then capable of development either with or without fertilization. If it is not fertilized, as must necessarily be the case unless the mother has copulated, development takes place at once without the body of the mother, and a male is produced; but if the egg is fertilized, it takes up yolk and acquires a resistant shell, which ordinarily prevents its development until the following season; that is, it becomes a 'winter egg.' From such eggs there hatch invariably agamic females."

In the *Heterakis*, *Lygacus* and *Euschistus*, and this whole series of species the size, quality, and power of the centrosome, or that part of the cell from which the aster is produced, are the same in either the male or the female. *The difference in the zygote of these animals is simply the greater number of chromosomes in the female and at least one less in the male. The number of chromosomes may vary in either the ova or spermatozoa, the effect of which is precisely the same as adding just a little larger centrosome to a given quantity of chromatin for the production of a male.*

" In *Heterakis*, for example, all the mature eggs receive five chromosomes, while half the spermatozoa receive five and half but four. A moment's consideration shows that the characteristic diploid combination of the male will rise upon fertilization of the egg by a sperma-

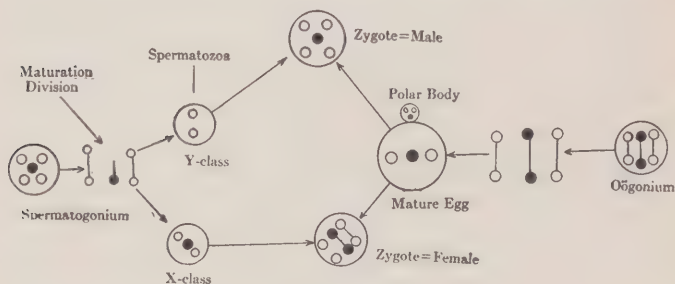


FIG. 45.

tozoön of the 'Y'-class (lacking X), the female combination upon fertilization by a spermatozoön of the 'X'-class. Fig. 45 shows this in diagram, and the result may be formulated as follows:

Egg X + spermatozoön no X = Zygote X (male),

Egg X + spermatozoön X = Zygote XX (female),

the nucleus being otherwise of identical composition.

" In the type represented by *Lygacus* or *Euschistus*, where a Y-element ('small idiochromosome') accompanies the X ('large idiochromosome') the same conclusion is shown even more clearly; for in many species the Y-element is the smallest of all the chromosomes and is therefore readily recognizable. In all such cases—as was first shown by Miss Stevens in the *Coleoptera* and the writer in the *Hemiptera*—this chromosome is confined to the male, while in the female its place is taken

by a second X-chromosome ('large idiochromosome'). The female diploid groups contain accordingly XX, the male XY (being otherwise identical); and upon reduction each mature egg contains one X, and half Y. Obviously, therefore, the same fertilization-formulas apply as in the former case, if Y be inserted in its proper place, *i.e.*,

Egg X + spermatozoön Y = XY (male),

Egg X + spermatozoön X = XX (female).

The result is still more strikingly shown in cases where the X-element consists of two or more components. Whatever be their number in the diploid group of the male—two in *Syromaster* or *Fitchia*, three in *Prionidus* or *Sinea*, four in *Gelastocoris*—twice this number appear in the female groups. Thus the general formulas $X + X = \text{Female}$ and $X + Y = \text{male}$ (in which Y may = zero) are applicable to the chromosome-combinations characteristic of the two sexes throughout this whole series of species, whatever be the composition of the X element" (Wilson).

In comparing the size of male and female, the male is almost without exception the larger, although both male and female may have been reared in the same environment, and with all the food of the same quality either could consume. In the human family the average weight for the male, according to my statistics, is 155 lbs., that of the female 127 lbs. These are the average weights of one thousand married women and men. In the bovine family the difference is still greater: while the weight of a cow is from 600 lbs. to 900 lbs., the weight of a bull is from 900 to 1800 lbs. This great difference is not caused by the stimulus produced by the

absorption of spermatozoa, as the castrated bull (a steer) will reach the same size as the bull, thus demonstrating the inefficacy of the absorption of spermatozoa to stimulate growth; neither will the removal of the ovaries stimulate growth in the female to the size of the male. All of these conditions prevail throughout the mammal group of animals. In the bird group of animals, the male is larger than the female: in the common fowl, the weight of the male is from 8 to 12 lbs., that of the female from 4 to 8 lbs. In the turkey, the weight of the male is from 10 to 20 lbs., that of the female from 6 to 11 lbs. The capon will grow to the same size as the cock, while the removal of the ovary will not stimulate the growth of the hen. This law should apply equally to the reptile and fish groups of animals, but it will be very hard to prove, because the male is subjected to different conditions from those acting upon the female. Moreover, in the fish family it will be hard to determine the sex in the young, and to give both an equal chance for development. The underlying cause in the production of males and females must of necessity be decided and powerful, to effect such a great difference in the manifestation of cell life. The cell of a large animal is no larger than that of a small animal, but the large animal's body contains more cells.

This great difference is produced by the introduction of the middle piece or body along with the nucleus of the spermatozoön. The fact that the nucleus or head is necessarily larger and the entire spermatozoön younger when a male is produced, may possibly account for the stimulus to a greater cell production in the male. The middle piece or body of the spermatozoön is a powerful

stimulus to cell-production, and from it, apart of the attraction-sphere, at least the astral rays and the spindle-fibres are developed. Now that we know that the male receives this large portion of the spermatozoön and that the female does not, we can very readily understand why a male child inherits the sexual characters of his father, while the daughter does not. The male characteristics are handed down directly in this part of the spermatozoön, or at least they are developed by it.

When this part of the spermatozoön enters the ovum a male is produced regardless of anything which may take place afterward. This fact is unquestionable in the higher order of animals, and I seriously doubt whether it can be different in any of the lower animals. Mr. Charles Darwin gives some very valuable information along this line in "The Descent of Man," Part II., Sexual Selection.

"Inheritance as Limited by Sex.—The equal transmission of characters to both sexes is the commonest form of inheritance, at least with those animals which do not present strongly marked sexual differences, and indeed with many of those. But characters are somewhat commonly transferred exclusively to that sex in which they first appear. Ample evidence on this hand has been advanced in my work on 'Variation Under Domestication,' but a few instances may here be given. There are breeds of sheep and goat, in which the horns of the male differ greatly in shape from those of the female; and these differences acquired under domestication are regularly transmitted to the same sex. As a rule, it is the female alone in cats which are tortoise-shell, the corresponding color in the male being rusty-red.

With most breeds of the fowl the characters proper to each sex are transmitted to the same sex alone. So general is this form of transmission that it is an anomaly when variations in certain breeds are transmitted equally to both sexes. There are also certain sub-breeds of the fowl in which the males can hardly be distinguished from one another, while the females differ considerably in color. The sexes of the pigeon in the parent-species do not differ in any external character; nevertheless, in certain domesticated breeds the male is colored differently from the female.

“The wattle in the English carrier pigeon and the crop in the pouter are more highly developed in the male than in the female; and, although these characters have been gained through long-continued selection by man, the slight differences between the sexes are wholly due to the form of inheritance which has prevailed; for they have arisen, not from, but rather in opposition to, the wish of the breeder. In all the species of deer but one the horns are developed only in the males, though certainly transmitted through the females and capable of abnormal development in them. In several kinds of antelopes only the males are provided with horns, while in the greater number both sexes bear horns. In the merino breed of sheep the rams alone bear horns.

“In most of the species of the splendid family of the pheasants, the males differ conspicuously from the females, and they acquire their ornaments at a rather late period of life. The male and female peacock differ conspicuously from each other in almost every part of their plumage, except in the elegant head-crest, which is common to both sexes. The sexes of dogs do not differ,

except that in certain breeds, especially in the Scotch deer hound, the male is much larger and heavier than the female."

It is not only the size of the male that is thus influenced, for every cell in the entire structure, the contour of the body, weight, offensive and defensive appendages, color, shape and quantity of hair and plumage, may be and often are affected.

Fertilization of the ova of the fish may take place in the Fallopian tubes, or after their extrusion from the body of the female fish. The "Encyclopædia Britannica" states: "Among fishes viviparous birth occurs more commonly: in some Teleosteans the young develop within the ovaries; in many sharks and dogfish the development takes place within the oviduct, and in one case (*Mustelus alevis*) an actual placenta is formed by the interdigitation of folds of the yolk sac with those of the oviduct. Even the terrestrial amphibians usually lay their eggs in water, yet in some types, notably the Alpine salamander (*Salamandria atra*), development takes place within the oviduct. That this is a clear case of adaptation to the eminently terrestrial environment has indeed been well shown by experiments in which the young larvæ, taken from the parent and transferred to pond water, developed like ordinary newts."

Almost all birds and reptiles are oviparous, the extinct *Ichthyosaurus* is the sole exception. Fertilization of the reptile ovum may take place either in the ovary or in the Fallopian tubes; however, this point has not been determined. Fertilization of the ovum in the whole bird family is almost sure to take place while the ovum is still in the ovary. The ovum of a bird grows to a very large

size while in the Graafian follicle and thus diminishes the thickness of the investing membrane of the ovary immediately covering the follicle, the discus proligerus, and the membrana granulosa to such an extent that it offers but little resistance to the long (from two to three times that of man), peculiarly shaped, active, sharply pointed heads of the spermatozoa which are often provided with a sharp-pointed acrosome. Fig. 31 shows a case in which a spermatozoon pierced a red blood corpuscle through its long axis. I saw this in a specimen of semen taken from a lacerated testicle of a rooster which had just been struck and killed by a train. In Fig. 32 are specimens from the same rooster, showing the sex-membrane which has been detached from the nucleus. The spermatozoa of the fowl soon die under the cover glass; the best of them live only two hours and a half at the temperature of 85° Fahr. When the ovum or yolk enters the oviduct and passes through the first five or six centimetres of its length, where the mucous membrane is smooth and transparent, the yolk absorbs a certain quantity of fluid, which is increased as the egg passes through the first and second divisions of the tube. It is almost incomprehensible how the spermatozoa of a bird can live and maintain their position in this duct for eighteen days, when such an abundance of albuminous fluid is secreted by its lining membrane every day for the production of the egg.

When a bird is mated from twelve to fifteen days prior to the maturity of the ovum in the ovary, the spermatozoa encounter great resistance in perforating the thick membranes covering the ovum; thus they consume both time and energy, and are reduced both mechanically

and physically to the female-producing quality. In other words, when a membrane is stretched from fifty to one hundred and fifty times its natural size it is more readily and easily pierced. Some male birds are very inactive sexually, in which case the semen accumulates in the vesiculæ seminales, spermatic cord, and the seminiferous tubules in the testicle, all of which become filled with aged, female-producing spermatozoa before the secretion leaves the vesiculæ seminales. This statement is confirmed by all observing men who breed fowl, and who know that an old inactive cock produces female offspring. In January, 1910, I purchased twelve common barnyard hens and one male fowl from one Mr. B. The ages of the hens ranged from two to four years, while the male was two or three years old, weighed nine pounds, and proved to be moderately active. They were placed in two Philo coops, six females in one and six females with the male in the other. They were fed as advised by Mr. Philo and very soon they responded with many eggs. Each hen was banded and numbered and kept confined in the coop; the male was kept in one coop with the six hens until the best layers were sorted out by the use of the U. S. trap nest in each coop. Among the twelve hens there were eight good layers that laid every day, and these were all placed in one coop and kept there by themselves for thirty days, when all possibility of a previous fertilization of the eggs had passed. During this time some of the hens had stopped laying, and the others were mated. However, by close attention for a few days all were again laying and promptly mated as soon as they began to lay. The male fowl had been kept with four hens all along and had access to the laying hens only as

indicated. Now, according to all information I had on the subject, the spermatozoa should enter the oviduct and make their way to its upper section, where they should wait for a time until the ovum appeared, when some one of the spermatozoa should fertilize it. According to this theory, the first eggs laid after mating should produce males, and those laid later females. The experiment showed quite a different result. The result was a run of males almost unbroken up to and including those eggs laid twenty-four days after mating. This indicated that fertilization of the ova followed soon if not immediately after mating and that the sex was determined at that moment. I used two of the Cycle Hatchers, manufactured by E. R. Philo, Elmira, N. Y., either of which holds fifty eggs. The trap nest was used, each egg was dated the day it was laid, and bore the same number as the hen that had laid it. All of the eggs from the eight hens were thus numbered and dated, stored away in cotton wool, in a room where there was neither fire nor ice, and allowed to remain until fifty had accumulated when they were placed in the incubator. The eggs laid for twenty-six days after insemination were thus stored and incubated. All went well with the first incubator until the seventh day, when something went wrong with the thermometer, the temperature fell, and it was not discovered soon enough to save the eggs. In the second and last incubation, only eleven were advanced far enough to enable me to distinguish the sex, and this was the result: Hen No. 67 laid on the 21st, 23d, and 24th days after mating, and all the eggs produced males; 25th, the same hen laid a female-producing egg. No. 71 laid on the 7th, 8th, 11th, and 13th days

after mating, and all the eggs were male. No. 70 laid on the 10th, 14th, and 18th days after mating, all eggs were males. No. 74 laid on the 24th day after mating, also a male. A very small quantity of chicks, but an immense quantity of knowledge. By using this simple method one can produce practically all male chickens. Any animal in the prime of life, as the male fowl in this instance, will produce spermatozoa that will retain the male-producing quality longer than at any other period of life.

The rule, therefore, is: Isolate the hens until they begin to lay, then mate with a male in the prime of life, one that has been with a few hens all along, and most of your chickens will be male, excepting a very few. In such a case the spermatozoa are all young and male-producing, for the vesiculæ seminales have been kept empty, the spermatic cord has been drained, this in turn has drained the seminiferous tubules, and the spermatozoa are young and active all along the seminal canal. When the spermatozoon passes through the oviduct to the Graafian follicle of the ovary it pierces the very thin membrane covering the ovum and fertilizes the egg, and when this has been accomplished the sex has been determined. If the middle piece of the spermatozoon is separated from the nucleus, the latter alone enters the cytoplasm of the egg, the middle piece remains outside, and a female is produced, while if the nucleus is large, the middle piece follows it into the cytoplasm of the ovum, and a male results. Now, in order to change the sex-producing quality of the cock above referred to, he was isolated for six weeks or longer and not allowed to mate; after that period the following hens

were mated in the order given, with the result given below.

On the 3d day of April, 1910, the following hens, bearing bands numbered 66, 70, 71, 72, and 73, were mated with the cock, which had been kept isolated for more than six weeks. No male had had access to the hens for thirty-five days, when they were mated in the order given (see page 173).

In the above experiment three hens were used to hatch the eggs; one hen taking all the eggs which had accumulated up to the 9th of the month, a second hen taking all those laid between the 9th and the 18th, and a third hen taking all those laid between the 18th and the 25th. While this is not so good a result as the farmer usually gets in number, it is as good as one could hope for in doing this work. The facts that the aged spermatozoa produce females and that the spermatozoa can become aged and female-producing while in the male generative organs are beautifully brought out. It will be evident, therefore, that the sex can be controlled in the bird family in a very practical way, and that almost all males or all females may be produced at will.

The birds produced from the first eggs laid after mating are stronger, grow up faster, and make larger, healthier, and more thrifty birds. The first eggs laid after mating also hatch just a little sooner, and the chicks almost always consume all the albumen in the egg; they break the shell, very soon bounce out, look around, and act as if the whole world were made for them. On the other hand, the birds produced from the eggs laid in the latter part of the mating are hatched a little later, and many of them do not consume all the albumen in the egg, it is left

April 3d, 1910, 5:30 P.M.

First Mating. No. 71.	Second Mating. No. 73.	Third Mating. No. 72.	Fourth Mating. No. 66.	Fifth Mating. No. 70.
1.....	.....	.....	.....	.....
2.....	.....	.....	.....	.....
3.....	.....	.....	.....	.....
4.....	.....	.....	.....	.....
5.....	.....	.....	Egg female	.....
6.....	Egg female	Egg 1/4 developed	.....	Egg female
7.....	Egg female	.....	Egg	Egg female
8.....	Egg female	.....	.....	.....
9.....	Egg female	Egg 1/2 developed	.....	.....
10.....	.....	Egg male	Egg male	Egg male
11.....	Egg female	Egg female	Egg	.....
12.....	Egg female	Egg female	Egg	.....
13.....	Egg female	Egg female	.....	Egg male
14.....	.....	Egg male	Egg	Egg male
15.....	Egg male	Egg female	Egg	Egg male
16.....	Egg non-fertile	Egg female	Egg	Egg female
17.....	Egg non-fertile	Egg male	.....	.....
18.....	Egg non-fertile	Egg female	.....	.....
19.....	.....	.....	.....	.....
20.....	Egg non-fertile	Egg female	.....	Egg male
21.....	.....	Egg non-fertile	.....	.....
22.....	Egg small germ	.....	.....	Egg non-fertile
23.....	Egg non-fertile	Egg non-fertile	.....	Egg non-fertile
24.....	.....	Egg non-fertile	.....	.....
25.....	Non-fertile	.....	.....	.....

in the shell and lost. The birds, moreover, are slow to come out of the shell after it is first broken, are often too weak to make their way out unaided, and wait until some one helps them out. They are feeble and delicate, grow up slowly, and remain small and puny through life. By some care in mating, by selecting for hatching only the first four eggs from an old hen, and by breeding from these, the size of the birds could be doubled in a few generations.

The dog, being a mammal, can be used to advantage in experimenting for the determination of sex, on account of the period of heat being well marked and lasting as a rule for several days. The phenomenon known as heat in the lower mammals resembles, in many essential respects, menstruation in human beings, and these functions may be regarded as homologous. Heat is a period of sexual excitement which recurs in the female dog at intervals of from twelve to sixteen weeks, though in some it may not occur oftener than once or twice in a year. The condition is accompanied by changes which resemble those of menstruation. The external genital organs become swollen and a discharge of mucus takes place from the uterus. The mucous membrane of the canine uterus undergoes histological changes similar to those of menstruation; that is, the membrane increases in size, becomes congested with blood, and exhibits a phase of degeneration during which some of the epithelial lining may be cast off and some hemorrhage occur. As in the case of the menstrual period, the heat period or œstrum cycle may be divided into four subperiods (Marshall and Jolly): the proœstrum, during which the genital organs are congested and swollen, corresponds

with menstruation; the œstrum, the period of sexual desire; the metœstrum, the period of repair and return to normal conditions, and the anœstrum, the period of rest. The proœstrum is caused by the active development of one or several Graafian follicles to maturity, producing congestion of the ovaries. When the Graafian follicle has advanced to, and protrudes from, the surface of the ovary the pressure in the organ is to a great extent relieved, then the more active congestion subsides. This condition may last from three to nine days, but in some dogs it is not so marked as to be noticeable. As the active congestion of the ovaries subsides it is superseded by œstrum, the period of sexual desire, when the female will admit the male. This period lasts until all the Graafian follicles are ruptured, which is from one to fifteen days. If the hymen or vagina is lacerated by the bulbus glandis of the male during coitus, which is often the case in both nulliparous and multiparous dogs, or when all the Graafian follicles are ruptured, the female will not admit the male. This period is followed by metœstrum, repair of the ovaries in the immediate section of the ruptured Graafian follicles, when the swelling and congestion of the vulva and vagina subside; then anœstrum, the period of rest, is established.

Fertilization of the ovum in the dog family does not take place until rupture of the Graafian follicle occurs; then, if the ovum has not been extruded from the follicle, it may be fertilized while still in the ovary, or else in the ovarian bursa, in either horn of the uterus, or in the uterus.

Rupture of the Graafian follicle usually takes place between the fifth and fourteenth days of the œstrum

period, though it may take place at any time during this period.

To produce all females in the dog: Allow one sexual connection the first day the female will admit the male; then protect the female from all dogs, feed lightly for five days, using very little if any meat, keep her in a comfortable place for sixteen days, after that give her her liberty, and she will produce six females to one male. This result is caused by the spermatozoa being partly aged in the male generative organs, and by their waiting for the rupture of the Graafian follicles in the female before they can fertilize the ovum. The fact that the male dog has had but one sexual intercourse has prevented the presence of young spermatozoa in the semen, since that first ejected is always more or less aged. By feeding the female lightly engorgement of the intestinal canal is prevented, and the blood-vessels contain less of highly nutritious blood, both of which conditions would go far toward augmenting the rupture of the Graafian follicles. Now to reverse the conditions and produce males: As soon as the female dog shows that she will take the male, see that sexual union is prevented for ten days, then use a male that has had sexual union three or four times the day previous with some other female dog; this will insure all male offspring. In this case the spermatozoa are young when they leave the male dog and enter the female generative organs; they do not wait long, if at all, for the rupture of the Graafian follicles; fertilization of the ovum takes place immediately or very soon after copulation. In this case there are not so many pups produced, as some of the ova will have passed out before the sexual union. The following is

the result of experiments along this line, conducted by myself:—

No. 1. One female spaniel dog, belonging to one Mr. H., a merchant, went in heat, and sexual union was prevented for ten to twelve days; littered only two male pups.

No. 2. One female black mongrel dog, weight 35 lbs., aged 3 years, lean and poorly fed, in which œstrum began on March 29th, 1910; sexual union was prevented until 9 o'clock P.M., April 11, 1910. On June 9, 1910, she gave birth to two male pups.

No. 3. One female yellow mongrel dog, weight 28 lbs., very lean and poorly fed, aged 4 years; œstrum began on April 7th, 1910, sexual union following on night of the same day. In this case the hymen and vulva were badly lacerated by the bulbus glandis of the male. All swelling about the vulva passed away on April 22d, 1910, when she would not take the male. On June 8th, 1910, she gave birth to one male and six female pups.

No. 4. One female black bird dog, weight 36 lbs., aged 3 years, lean and poorly fed. Œstrum began on April 12th, 1910; sexual union was prevented for nine days, when all swelling about the vulva had passed away, then she would not allow a dog to touch her.

No. 5. One female white bulldog, weight 45 lbs., in fair condition and very well fed, aged 5 years. Gave birth to two male and four female pups on June 5th, 1910. Three of the pups were dead at birth and all the rest died in a few days, cause unknown. Here the female dog failed to show any sign of œstrum and went unobserved by a very watchful keeper.

No. 6. One female sheep dog, weight 38 lbs., in good

condition, and well fed during œstrum. (Estrum began on June 3d, 1910, copulation took place on the following day. In this case the male was 18 months old, and it is probable that he had been with some other female dog the day previous. In August the bitch gave birth to two female and three male pups. The result in this case is apparently reversed, but when we consider the youth of the spermatozoa from the male and the fact that the female had been much better fed during œstrum than she was in a habit of being, it is about what one might anticipate. The same female dog went in œstrum in February, 1911, cohabitation followed on the second or third day of œstrum, and she littered six female pups in April.

No. 7. One small female yellow mongrel dog, weight 23 lbs., aged 4 years, lean, poorly fed. (Estrum began August 16th, 1910; sexual union was prevented until August 23d; on October 23d she gave birth to one female and three male pups.

In the Human Family.—In taking up this problem as applying to the human family, the results are much more convincing and satisfactory. When the human being can see how well and truly this law is fulfilled in his own family, its operation is more convincing than any or all the results one might obtain in the animal kingdom by experimenting for the next century. For this reason the following work has been done in the human family. The human species is not unlike many insects, birds, and mammals, many of which have their period for courtship, though they do not reach the superlative degree as seen in man. In the animal kingdom, insemination takes place at the conclusion of a successful courtship, without

the formalities of legal sanction and the ministerial benediction; but this is not the case in the human family, for very many reasons. The generative organs of a woman are so different from those of insects, birds, and very many mammals, that it becomes necessary for her to consult a calendar before she is able to name a date for the happy nuptials, which date must not be too close to the menstruation before marriage, nor too near the menstruation which succeeds the honeymoon. It must be made to fall on a Wednesday, and not on a Wednesday coming on the thirteenth of the month. The thirteenth is considered an unlucky date and is avoided for that reason. If the date for marriage is set near the ending of menstruation, it might be delayed from some cause and run into the marriage date. Again, if the date is made very late after menstruation, the succeeding menstruation is liable to be hastened and come on six or eight days prematurely, owing to the excitement incident to marriage. The date must come on a Wednesday, for such is the custom. Though there are many conditions and circumstances to be considered, those designated above are the predominating factors in setting the date for marriage. There are very few if any women whose menstruation is absolutely regular. It will vary from two to five days or longer. The flow may continue for about the same number of days, but the duration will vary in different women, and in the same woman at different times. For this reason it is necessary to set the date for marriage as near as possible midway between the cessation of one menstrual flow and the beginning of the anticipated menstruation, varying a few days to have it on a convenient day or date. The dates for marriage

given in the following calendar follow the cessation of the menstrual flow as near as they could be set with safety; for the arrangement is usually made two months prior to marriage, and they could not be set a week later, for fear they would run into the first menstruation after marriage.

CALENDAR, 1911

JANUARY

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1	2	3	4 Men. begins	5	6	7 Men. ceases
8	9	10	11	12	13	14
15	16	17	18 Marriage	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

5	6	7	1 Men. begins	2	3	4 Men. ceases
12	13	14	8	9	10	11
19	20	21	15 Marriage	16	17	18
26	27	28	22	23	24	25

MARCH

5	6	7	1 Men. begins	2	3	4 Men. ceases
12	13	14	8	9	10	11
19	20	21	15 Marriage	16	17	18
26	27	28	22	23	24	25
			29 Men. begins	30	31	

APRIL

2	3	4	5	6	7	1 Men. ceases
9	10	11	12 Marriage	13	14	8
16	17	18	19	20	21	15
23	24	25	26 Men. begins	27	28	22
30						29 Men. ceases

CALENDAR, 1911.—*Continued*

MAY

Sun.	Mon.	Tues.	Wed.	Fri.	Thurs.	Sat.
	1	2	3	4	5	6
7	8	9	10 Marriage	11	12	13
14	15	16	17	18	19	20
21	22	23	24 Men. begins	25	26	27 Men. ceases
28	29	30	31			

JUNE

				1	2	3
4	5	6	7 Marriage	8	9	10
11	12	13	14	15	16	17
18	19	20	21 Men. begins	22	23	24 Men. ceases
25	26	27	28	29	30	

JULY

						1
2	3	4	5 Marriage	6	7	8
9	10	11	12	13	14	15
16	17	18	19 Men. begins	20	21	22 Men. ceases
23	24	25	26	27	28	29
30	31					

AUGUST

		1	2 Marriage	3	4	5
6	7	8	9	10	11	12
13	14	15	16 Men. begins	17	18	19 Men. ceases
20	21	22	23	24	25	26
27	28	29	30 Marriage	31		

CALENDAR, 1911.—*Continued*

SEPTEMBER

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
					1	2
3	4	5	6	7	8	9
10	11	12	13 Men. begins	14	15	16 Men. ceases
17	18	19	20	21	22	23
24	25	26	27 Marriage	28	29	30

OCTOBER

1	2	3	4	5	6	7
8	9	10	11 Men. begins	12	13	14 Men. ceases
15	16	17	18	19	20	21
22	23	24	25 Marriage	26	27	28
29	30	31				

NOVEMBER

5	6	7	1	2	3	4
12	13	14	8 Men. begins	9	10	11 Men. ceases
19	20	21	15	16	17	18
26	27	28	22 Marriage	23	24	25
			29	30		

DECEMBER

3	4	5	6 Men. begins	7	1	2
10	11	12	13	14	8	9 Men. ceases
17	18	19	20 Marriage	21	15	16
24	25	26	27	28	22	23
31					29	30

In the above cases, insemination would usually follow on the twelfth day after the cessation of menstruation.

If the cessation of menstruation had come on Wednesday, Thursday, or Friday, instead of Saturday, insemination would not have followed until the fifteenth, fourteenth, and thirteenth day, respectively, after menstruation. After the sixteenth day, it is too late in most cases to produce pregnancy. If the date of marriage were changed and made a week earlier, when the cessation of menstruation followed on Tuesday, Wednesday, Thursday, and Friday, instead of Saturday, a female child would be produced, for insemination following seven days after menstruation will almost always produce a female; if still nearer the period, a female is sure to be produced. Now at least we can understand why insemination does not follow very soon after the menstruation before marriage. If this were the case the number of children produced during the honeymoon should be overwhelmingly male; while those produced immediately after the first menstruation following marriage should be overwhelmingly female. If there ever is a time during the matrimonial career at which insemination takes place soon after the cessation of menstruation, it is that following the first menstruation.

Below is given the result of one thousand marriages; the records in two-thirds of the cases were taken directly from the family Bible, and most of them are absolutely correct. The fact that 157 children are born nine months after marriage to 983 women, and that 189 children are born ten months after marriage to 826 women permanently establishes the point that only 7 per cent more pregnancies follow early insemination after cessation of menstruation.

FIRST PREGNANCY AFTER MARRIAGE OF 1,000 WOMEN.

	Boys.	Girls.	Total.	Per cent of Pregnancies
8th month	5	12	17	1.6
9th "	129	28	157	15.7
10th "	53	136	189	22.7
11th "	63	35	98	15.1
12th "	46	30	76	13.5
13th "	27	33	60	12.2
14th "	30	36	66	16.0
15th "	14	13	27	7.8
16th "	16	11	27	8.5
17th " and later	160	131	291	100.0
Total births	543	465	1,008	

NUMBER OF CHILDREN BORN TO 1,000 WOMEN.

Pregnancies.	Boys.	Girls.	Total.
1st	543	465	1,008
2d	425	444	869
3d	360	347	707
4th	285	275	560
5th	220	212	432
6th	174	160	334
7th	119	120	239
8th	89	92	181
9th	75	58	133
10th	41	28	69
11th	21	20	41
12th	14	15	29
13th	7	9	16
14th	2	8	10
15th	2	5	7
16th	2	1	3
Total	2,379	2,259	4,638

NUMBER OF TWINS BORN IN 4,600 LABORS.

Labor.	Both Boys.	Both Girls.	Girl and Boy.	Total.
1st.....	3	3	2	8
2d.....	2	2	4	8
3d.....	1	2	2	5
4th.....	1	0	1	2
5th.....	1	3	1	5
6th.....	2	1	0	3
8th.....	1	..	..	1
9th.....	1	..	2	3
12th.....	1	..	..	1
14th.....	..	1	..	1
15th.....	..	..	1	1
Total No. of labors....	13	12	13	38
Total No. of children...	26	24	26	76

OCCUPATIONS OF THE MEN.

Farmers.....	370	Millers.....	8
Carpenters.....	143	Bakers.....	3
Miners.....	77	Lumbermen.....	21
Merchants.....	102	Teachers.....	42
Physicians.....	30	Financiers.....	25
Barristers.....	12	Salesmen.....	39
Ministers.....	19	Railroad conductors....	78
Dental surgeons.....	13	Powder makers.....	9
Hotel proprietors.....	9		
		Total.....	1,000

The following table gives the age, weight, and height of fifty-three men and women who produced male children ten months after marriage.

MEN.			WOMEN.		
Age.	Weight.	Height.	Age.	Weight.	Height.
18	160	5' 10"	14	136	5' 6"
30	152	5' 8"	22	132	5'
23	146	6'	23	126	5' 5"
53	167	5' 8"	17	155	5' 4"
30	131	6'	30	116	5' 6"
19	150	5' 8"	23	125	5' 3"
22	150	5' 10"	19	120	5' 5"

MEN.			WOMEN.		
Age.	Weight.	Height.	Age.	Weight.	Height.
23	160	5' 8"	18	140	5' 7"
21	178	6'	28	160	5' 4"
23	150	5' 11"	21	115	5' 3"
24	170	6' 2"	23	116	5' 2"
26	148	6'	28	184	5' 6"
24	180	5' 9"	..	120	5' 2"
24	180	6' 1"	24	130	5' 4"
26	167	6' 2"	16	106	5' 3"
29	152	6'	24	120	5' 4"
23	150	5' 10"	21	130	5' 5"
22	156	5' 10"	29	110	5' 6"
25	156	5' 11"	23	155	5' 6"
26	150	6'	19	125	5' 6"
24	125	5' 10"	21	140	5' 5"
23	120	5' 6"	16	140	5' 4"
23	140	5' 4"	18	140	5' 8"
26	163	5' 10"	23	135	5' 5"
23	145	6'	18	120	5' 6"
24	140	5' 6"	28	140	5' 3"
32	140	6'	21	116	5' 4"
25	172	5' 8"	17	122	5' 4"
21	170	5' 10"	21	150	5' 5"
25	170	5' 11"	20	150	5' 4"
44	165	5' 10"	20	140	5' 4"
29	120	5' 9"	19	90	5'
23	130	5' 6"	23	110	5'
25	176	5' 11"	24	170	5' 8"
23	130	5' 6"	18	130	5' 7"
16	170	6' 2"	17	118	5'
22	150	6'	21	125	5' 6"
26	165	5'	21	108	5' 4"
29	157	5' 10"	23	106	5' 4"
60	160	6'	18	128	5' 6"
24	160	5' 10"	22	116	5' 4"
30	155	5' 9"	26	125	5' 3"
25	165	5' 9"	21	125	5' 4"
32	150	5' 7"	17	128	5' 7"
52	173	6'	31	95	5' 5"
22	150	5' 11"	24	115	5'
36	170	5' 9"	21	110	5' 9"
28	130	5' 6"	21	115	5' 6"
22	145	5' 9"	23	115	5' 4"
21	130	5' 5"	19	120	5' 4"
27	150	5' 7"	26	106	5' 2"
21	150	5' 10"	17	125	5' 4"
29	130	5' 9"	26	150	5' 4"
Aver. 27	152	5' 9"	Aver. 22	127	5' 4"

The following are those who produced female children nine months after marriage.

HUSBAND.			WIFE.		
Age.	Weight.	Height.	Age.	Weight.	Height.
42	180	5' 11"	22	105	5' 3"
24	140	5' 9"	21	130	5' 6"
24	136	5' 7"	20	140	5' 7"
29	150	5' 8"	24	122	5' 2"
20	148	5' 4"	19	140	5' 4"
42	165	5' 8"	17	130	5' 3"
24	175	5' 10"	23	150	5' 5"
29	150	6'	41	125	5' 11"
19	185	5' 10"	17	120	5' 4"
24	160	6'	19	150	5' 5"
23	140	5' 8"	21	115	5' 2"
21	148	5' 8"	22	129	5' 9"
37	140	5' 6"	21	110	5'
28	130	5' 5"	20	110	5' 5"
20	150	6'	23	140	5' 4"
26	150	6'	25	130	5' 2"
22	135	5' 11"	27	135	5' 8"
27	175	5' 10"	21	130	5' 6"
30	155	5' 8"	19	135	5' 5"
33	150	6'	24	135	5' 4"
21	144	5' 10"	25	144	5' 6"
23	148	5' 9"	21	125	5' 8"
28	135	5' 8"	35	100	5' 4"
25	145	5' 9"	17	95	5'
22	140	5' 6"	18	110	5'
30	170	6'	18	120	5' 5"
19	178	5' 10"	22	160	5' 4"
30	148	5' 7"	21	130	5' 4"
Aver. 27	152	5' 9"	Aver. 22	127	5' 4"
Total.....			28		

Of the one hundred and fifty-seven children produced nine months after marriage, only twenty-eight are female; twenty of these are in cases in which the father or mother, or both, were twenty-four years old or older (see Secondary laws, age and occupation). This leaves eight cases,

six of which were in hard-working farmers' daughters, in a class of people who would not be likely to give menstruation the serious consideration that others would, in setting the date for marriage. Two of them were of a class that would use the best judgment and discretion in setting a date for marriage, and they might be supposed to have set the day soon after the cessation of menstruation. The occupations of the husbands are: fifteen farmers, four merchants, three civil engineers, one miller, one baker, one laborer, one druggist, one teacher, and one physician.

Of the one hundred and eighty-nine children born to the remaining eight hundred and twenty-six women, fifty-three are male, and one hundred and thirty-six are female. It may cause some surprise that there are so many boys resulting from these inseminations early after the cessation of menstruation; but when we consider that, in some at least, the insemination does not occur soon, and that in others the young male-producing spermatozoa are kept present by repeated inseminations, then the result is just what might have been anticipated. If insemination had stopped on the sixth day after the cessation of menstruation, there would have been at least forty boys less. The production of a girl can never be made quite so certain as that of a boy, for the reason that the male-producing spermatozoa move faster and keep in advance of the female-producing ones, and if the ovum has been extruded from the ovary at the time of insemination, the male-producing spermatozoa are sure to reach the ovum first. In both of these categories—where the male was produced where the female should have been, and the female produced where the male

should have been—the average age, weight, and height are the same, but the significant fact is that the weight of the men is less than the average of the 1,000, which is 155 lbs. The occupations of the husbands are: twenty-four farmers, four merchants, four carpenters, two blacksmiths, two bakers, two miners, two millers, two salesmen, two civil engineers, one physician, one minister, one coal-operator, one insurance solicitor, one railroad cashier, one stenographer, one United States deputy marshal, one station agent, and one whisky manufacturer. (See Table of Occupations, p. 185.)

Among the thousand women on record, eighty-two did not produce children until between two and three years after marriage; forty-one between three and four years; seven between four and five years; six between five and six year ; three between six and seven years; one between nine and ten years, and only one in the tenth year, after which period all were as prolific as those who conceived early after marriage.

Among the seventy-six twins produced in four thousand six hundred labors, there were thirteen cases in which both were males, both females in twelve, and in thirteen, one male and one female, which proportion shows a most beautiful rounding up of results by nature, and also that the statistical ratio of males to females is maintained.

The first record in history of anything having been done for the prevention of sterility appears in the marriage of Abram and Sarai (Gen. xi. 29-30). After many years of married life Abram lamenting said, Lord God, what wilt thou give me, seeing I go childless, and the steward of my house is this Eliezer of Damascus?

And Abram said, Behold, to me thou hast given no seed (Gen. xv. 2, 3). And when Abram was ninety years old and nine, the Lord appeared to Abram, and said unto him, I am the Almighty God; walk before me, and be thou perfect. And I will make my covenant between me and thee, and will multiply thee exceedingly. This is my covenant, which ye shall keep, between me and you and thy seed after thee: Every man child among you shall be circumcised. And ye shall circumcise the flesh of your foreskin; and it shall be a token of the covenant betwixt me and you. And he that is eight days old shall be circumcised among you, every man child in your generations, he that is born in the house or bought with money of any stranger, which is not of thy seed. In the selfsame day was Abraham circumcised, and Ishmael his son. And all the men of his house, born in the house, and bought with money of the stranger, were circumcised with him (Gen. xvii. 1-2, 10-12, 26, 27).

In this case we see the beginning of circumcision, the result of which is a son born to a man in his ninety-ninth year, from a childless woman in her ninetieth year, and six sons from the second wife. Ishmael, who was circumcised at the same time with his father Abraham, produced twelve male children. Abraham's six sons from Keturah were: Zambran, Jazar, Madan, Madian, Josabak, and Sous. The sons of Sous were: Sabathan and Dadan; the sons of Dadan were Latusim, and Assur, and Luom; the sons of Madian were Ephas, and Ophren, and Anoch, and Ebidas, and Eldas. The sons of Isaac were Esau and Jacob. Esau had five legitimate and one illegitimate sons. The daughters are not mentioned,

and the daughter of Ishmael is only incidentally given in Esau's marriage to her. The sons of Jacob (or Israel) were many. All the souls that came with Jacob into Egypt, which came out of his loins, besides Jacob's sons' wives, all the souls were threescore and six (Gen. xlv. 26). The number of female children from Jacob were only two to this time: his daughter Dinah, by Lea; and his granddaughter, Sarah, by Asher. And the children of Israel were fruitful, and increased abundantly, and multiplied, and waxed exceedingly mighty; and the land was filled with them. So great were the number of males born to the Israelites that the new king over Egypt, which knew not Joseph, gave the following instructions: "And the king of Egypt spake to the Hebrew midwives, of which the name of one was Shiprah, and the name of the other Puah; and he said, When ye do the office of a midwife to the Hebrew women, and see them upon the stools; if it be a son, then ye shall kill him; but if it be a daughter, then she shall live." Failing in this, the Pharaoh charged all his people, saying, "Every son that is born ye shall cast into the river, and every daughter ye shall save alive" (Ex. i. 7, 8, 15, 16, and 22). This injunction had not been given until about sixty years after the death of Joseph, which was about the time of the birth of Moses, who in his eightieth year conducted his nation safely out of the land of Egypt. The entire multitude of those that went out, including the women and children, was not easy to be numbered; but those that were of an age fit for war, were six hundred thousand. Now, all these were the offspring of Jacob, who had removed into Egypt two hundred and fifteen years before. That there was a great excess of males is shown

by the Midianites who sent their daughters near to the Israelite camp, that many of them might be taken for wives by the soldiers who would later accept the Midianite god for their own; so successful was this scheme that it became necessary for Moses to destroy twenty-four thousand of his own soldiers, to prevent further sedition, which never would have occurred had there been an equal number of females in the Israelite nation. Moses had one brother and one sister, and produced only two sons. Aaron, a brother of Moses, had four children, all of whom were male. Gideon had seventy sons by many wives; history fails to mention any daughters. Jair had thirty sons; if he had daughters, history fails to mention them. Eli had two sons. Saul, the first king of Israel, had three sons and two daughters. King David had eleven sons and one daughter, Tamar, a full sister of Absalom. Solomon had seven hundred wives and three hundred concubines, and produced only one son, Rehoboam; and this man produced only one son, Abijah. Abijah produced twenty-two sons and sixteen daughters by fourteen wives. Asa, a son of Abijah, became king of Jerusalem, and was succeeded by his only child and son, Jehoshaphat. Jehoshaphat is credited with the production of but one son, Jehoram, who succeeded him as king. These were the most virtuous, high, and easy-living families of the Jewish race, for a period of more than eleven hundred years. When any children were produced, they never failed to produce a male to succeed them. The preponderance of males in this race of people is beyond anything I had anticipated. This condition has been noted before by Mr. Charles Darwin who gives the following data: "It is a singular fact that

with Jews the proportion of male births is decidedly larger than with Christians; thus in Prussia the proportion is as one hundred and thirteen, in Breslau as one hundred and fourteen, and in Livonia as one hundred and twenty to one hundred; the Christian births in these countries being the same as usual; for instance, in Livonia as one hundred and four male to one hundred female."

The predominance of male-production in the Jewish nation is due to two conditions, either of which is capable of producing this result, but when both act together a male is almost sure to be produced.

These two conditions are:

1st. Circumcision of the male.

2d. The observance of the Levitical law by the female: in this she is instructed to wait seven days after the last day of the menstrual flow before allowing insemination.

1st. In case of circumcision of the male, the prepuce is removed, and the glans penis is left bare. In this condition it becomes less sensitive and tender to the touch, on account of its being continually dry and coming in contact and rubbing against the rough clothing the Jews usually wear. For this reason the seminal fluid is not ejected so early during the sexual act and the female is more liable to be brought to orgasm, which usually causes rupture of a Graafian follicle, and which may be produced from six to twelve days after cessation of the menstrual flow.

2d. The female having waited until the seventh day after the menstrual flow, the Graafian follicle is now about ready to rupture. In many cases it may be ruptured at the point of orgasm during cohabitation on

the seventh day after the menstrual flow; in which event the production of a male is almost inevitable.

These are the secrets of the great vitality of the Jewish nation for the past three thousand eight hundred and thirty years. By this method of child-production, the young active spermatozoa fertilize the well-matured ovum in its most vigorous state, with the result of producing the strongest child possible, one that is ever quick to think and act, and that possesses great power and stamina for immediate and continued exertion. All success through life depends upon these qualities, both individually and collectively.

Mr. Charles Darwin says: "It seems at first sight a mysterious fact that in different nations, under different conditions and climates, in Naples, Prussia, Westphalia, Holland, France, England, and the United States, the excess of male over female births is less when they are illegitimate than when legitimate." His explanation for this follows: "This has been explained by different writers in many different ways, as from the mothers being generally young, from the large proportion of first pregnancies, etc. But we have seen that male infants, from the large size of their heads, suffer more than female infants during parturition; and as the mothers of illegitimate children must be more liable than other women to undergo bad labors, from various causes, such as attempts at concealment by tight lacing, hard work, distress of the mind, etc., their male infants would proportionately suffer. And this probably is the most efficient of all the causes of the proportion of the males to females born alive being less among illegitimate children than among the legitimate." This to me does not touch the true

cause, which is given in the following: The male does not seek the harlot until the vesiculæ seminales are filled and distended with aged spermatozoa of many days' accumulation, and the harlot does not wait any settled length of time after the cessation of the menstrual flow before she allows insemination, but coition usually begins when the flow ends, in which case the Graafian follicle is not ruptured during the act, nor can it be for several days after the cessation of the menstrual flow; and during this time the Fallopian tubes are filled with aged female-producing spermatozoa. Female-production is further favored by the engorgement of the vesiculæ seminales with aged spermatozoa, which are ejected early during the sexual act, before the female has reached orgasm or received any shock, which is so necessary to rupture the Graafian follicle in male-production. The same condition prevails in the case of a heavy fat man, whose energy is consumed in locomotion with a consequent disinclination for cohabitation. He allows his vesiculæ seminales to become engorged with spermatozoa for many days, until most of them are dead, many are female-producing, and a very few are male-producing. During the sexual act they are ejected almost immediately upon the entrance of the penis into the vagina, before the female has reached orgasm or received any shock. The same explanation applies to the chaste man, to the weak debilitated man, and to men who are sexually inactive from any cause; all of whom are prone to female-production. In case the female remains in an apathetic condition during cohabitation, she feels no orgasm or shock, which is necessary to produce rupture of the Graafian follicle, as above stated. The apathetic con-

dition on the part of the female may be caused by the chaste life she has lived before; by her total ignorance of the sexual union; and by her lack of affection for her husband. Moreover, a weakened or debilitated condition of the female from any cause will go far toward producing female offspring.

After the thirty years' war in Germany, so many men had perished in battle, by disease, and by bad conditions incident to long wars, that there were two women for every man. For that reason some of the provinces relaxed their marriage laws and allowed a man to take two wives. The balance of the sexes, it is stated, at once began to restore itself, and before the end of the century the normal equilibrium had been reestablished. The wives under such conditions are more liable to late insemination after the menstrual flow, and by copulating less frequently, they are more passionate and susceptible to the sexual shock and orgasm which serve so well to rupture the Graafian follicle when it is well matured. On the other hand, the vesiculæ seminales of the husbands are kept free from an accumulation of old spermatozoa which are female-producing. The spermatozoa are produced very slowly in a hard-working man, and hence there is more room for the larger growth of the nuclei which thus acquire the male-producing quality. Besides, a small quantity of semen is not ejected so soon during sexual intercourse, and the prolongation of the act aids in bringing the female to orgasm, with the result above explained. Thus all conditions contribute to the production of males.

Punnett has given the official census of the county of London, 1901: "The metropolis is divided into 29 bor-

oughs. Exclusive of the city of London, with its peculiar conditions, we are left with 28 boroughs, having a total population of just over 4,500,000. For each of these boroughs the proportion of male to female infants under one year has been reckoned. The servant-keeping capacity has been taken as the guide to the relative wealth of the different boroughs, it being assumed that when a family is able to do so it will keep a servant. In table I the 28 boroughs are arranged in order of wealth (on the servant-keeping capacity basis), while at the same time the relative proportion of male and female infants is given. The 28 boroughs have been arranged in three groups: A, with a percentage of indoor servants less than 15 (100 families); B, with a percentage of over 15 but less than 30; and C, with a percentage of over 30. The relative proportion of male and female infants then works out to:—

99.5 males per 100 females: for group A.
 100.7 males per 100 females: for group B.
 102.2 males per 100 females: for group C.

	A	B	C
Male	20,309	23,327	11,038.
Female	20,413	23,159	10,841.

“While in a table of 5,225 children in Burke’s Peerage this condition is accentuated by a still greater increase of the male, as 107.6 males to 100 females.” The operating factors here are probably in both father and mother. Those women who have both the quality and quantity of food desired will mature a Graafian follicle sooner after menstruation than those who are deprived of the quality and in this case probably some are deprived of the quan-

tity of food desired. The better classes are more liable to defer the sexual union after menstruation than the poor. The vesiculæ seminales of the better classes are more liable to be drained of the aged female-producing spermatozoa. Both of the above conditions tend very materially to the production of males.

CASE 1.—A vigorous man, aged 23, weight 140 lbs., who had spermatorrhœa, married a woman, aged 26, weight 98 lbs. A male child was born to them nine months later. After that three daughters were born to them, the first about three years after the boy in 1874, a second daughter in 1876, and a third daughter in 1878. In this case the first insemination did not take place until the twelfth day after the menstrual flow, at which time the Graafian follicle ruptures in most cases from the slightest cause. On account of the spermatorrhœa, the production of females followed later insemination. This case shows us that, without the shock of orgasm, we can produce a male by inseminating at the proper time, and that female-production inevitably results from early insemination unaccompanied by the shock of orgasm on the part of the female.

CASE 2.—A man, aged 43, weight 165 lbs., married a woman aged 28, weight 135 lbs., waited until fourteen days after the last day of the menstrual flow to prevent the production of children. This was followed by a fine son in fourteen months after marriage and a second son three years later.

CASE 3.—A man, aged 24, weight 120 lbs., married a woman aged 20, weight 140 lbs., had a run of three daughters in succession and to prevent the further production of children did not copulate until twelve days after the

menstrual flow. This was followed by the production of four sons in succession.

CASE 4.—A man, aged 36, weight 125 lbs., married a woman aged 19, weight 135 lbs., produced three daughters in succession, and to prevent the production of more children deferred insemination until twelve days after the last day of the menstrual flow, and this was followed by the production of a son.

CASE 5.—A man, aged 23, weight 160 lbs., married a woman, aged 20, weight 165 lbs., produced two daughters in succession; at this time she was informed by one of her friends that she could produce boys by waiting nine days after the menstrual flow before insemination. She followed this advice and produced five sons in succession.

CHAPTER IX.

SECONDARY LAWS.

Maternal Secondary Laws.—The secondary conditions in the mother and father which go to determine the production of sex are many, any of which may be placed under one of the following divisions of the Maternal Secondary Laws:—

(1) Physical condition of the ovary and Fallopian tubes.

(2) Menstruation and ovulation.

(3) General condition of health.

(4) Quantity and quality of food consumed.

(5) Occupation.

(6) Maternal age.

(7) Climate and altitude, atmospheric conditions.

(8) Individual peculiarities.

(9) Circumstances of cohabitation.

Paternal Secondary Laws.—

(1) Physical condition of the testes and the seminal ducts, spermatic cord, vesiculæ seminales, and the urethra.

(2) Quantity and quality of food consumed by the individual.

(3) Vitality of the husband.

(4) Age.

(5) Occupation.

(6) Clothing about the loins.

- (7) Cohabitation.
- (8) Age at which puberty has been established.
- (9) Climate and altitude.

MATERNAL SECONDARY LAWS.

1st Maternal Secondary Law.—Physical condition of the ovary and Fallopian tubes.—Where we wish to control the production of sex it is most desirable to have the ovary in a perfectly normal condition in order that ovulation may take place at a fixed time after each menstruation, inasmuch as any pathological condition may hasten or retard ovulation. It is also necessary that the Fallopian tubes be in a normal condition to take up, transmit, and deliver to the uterus the ovum which has been matured and extruded from the Graafian follicle. The time consumed by the Fallopian tubes to deliver the ovum to the uterus from the Graafian follicle should not be longer than six hours; doubtless this is in many cases accomplished in a very few minutes, whereas in others it may be prolonged. Anything which may cause delay in the ovum reaching the Fallopian tube after its extrusion from the Graafian follicle will lessen the chance of sex control. The passage may be assisted and delay overcome by gravity, if the woman will lie on the side that produced the ovum, for from three to five hours just after insemination. This would cause the fluid and ovum from the Graafian follicle to gravitate to the fimbriated extremity of the tube, where it would be taken up and wafted toward the uterus. There is usually more or less pain or tenderness over the ovulating ovary just before, during, or after menstruation to indicate the

side. In case the ovulating ovary is unknown, then the woman should lie on the side which is the more comfortable, for from four to six hours—a period that will allow time for external migration of the ovum.

2d Maternal Secondary Law.—Menstruation and ovulation.—Menstruation is commonly taken to consist in the periodical discharge of blood from the uterus. This, the most conspicuous objective phenomenon, is, however, only one act in a complicated process, of which the genital system is the focus, but upon which the entire organism is at work. The ovary in which resides the *primum mobile* of this process becomes greatly enlarged from an active hyperæmia of the organ, which involves the entire vascular system of the pelvis. In a woman of the age of twenty-four, in her normal condition, when a Graafian follicle emerges from its dormant state to active development for the production of a mature ovum and its extrusion, the menstrual flow is usually its prodrome; if there are no abnormal conditions met with by the woman the follicle matures ready for rupture and extrusion midway between the last day of one menstruation and the first day of a succeeding one. For variations from this rule the reader is referred to all of the secondary laws. Cessation of the menstrual flow is sometimes closely followed by its return without apparent cause. This is probably due to the maturity of a second Graafian follicle, in which event two ova are to be reckoned with when it is desirable to control the sex. In these cases the last day of the recurring flow is to be taken as the date to determine the time at which insemination should take place, instead of the last day of the normal menstrual flow. The loss of a double quantity of blood will retard

the advancement to maturity of the second follicle, in most cases, as much as one day.

3d Maternal Secondary Law.—Health.—The state of the general health will play a great part in the development of a Graafian follicle. The normal condition will tend to produce an ovule regularly and on the anticipated time; if from any reason this condition is lowered, a delay of the maturation of the Graafian follicle will follow the menstruation. I shall mention a few of the more common pathological conditions which will produce a delay: the loss of an unusual quantity of blood during menstruation; the loss of blood from any cause; acute or chronic diarrhœa; hydragogue cathartics; continued overexertion; loss of sleep; profound shock produced from joy, sorrow, fear, fright, distress, or anything that will tend to lower the vitality or vigor of the individual. I think it best to wait for a normal condition, as children produced from an ovule matured under an abnormal condition are liable to deformity, birth-mark, and weakness of various parts of the body. The beginning of menstruation is the announcement of active development of the ovule, and it is from this time until the ovule has been extruded from the Graafian follicle that it is most receptive of impressions conveyed to it from the mother. A woman in good health has a full quantity of normal blood, which produces a smooth firm condition of the ovary; she is more susceptible to sexual passion; the sexual organs are readily filled and distended with blood; during the sexual union she is more active; her sexual organs become filled and engorged with blood, producing in them a hyperæsthetic condition which hastens orgasm; her ovaries are dis-

tended with blood to the point just short of rupture of the Graafian follicle, and when orgasm comes on, the follicle is instantly ruptured, the mucous membranes of the vagina, uterus, and Fallopian tubes are then flowing with a thin limpid mucous secretion, the ideal medium through which the spermatozoa readily pass to meet the ovum in the Fallopian tube. All of these conditions will lead to the production of a fine specimen of humanity, and the control of sex is at its maximum in such a case.

4th Maternal Secondary Law.—Quantity and quality of food consumed by the individual.—Where a carbohydrate or vegetable diet is used and not a great quantity consumed, a delay of the maturity and rupture of the Graafian follicle may be expected. Where a normal quantity of vegetables or carbohydrates and a moderate quantity of the proteids of meats and eggs are used, we may anticipate the maturity of the Graafian follicle in its normal period of time. Where there is a good quantity of both carbohydrates and proteids used we may anticipate a still earlier maturity and rupture of the Graafian follicle. If a male child is desired, the chance may be augmented by the mother using as much meat and fats as possible, and only so much starchy foods as is absolutely necessary to prevent their want being felt, just a day or two before the anticipated sexual union. This is due to the rapid assimilation of proteids and fats, which are stored in the blood-vessels, from which they are assimilated. When the blood is loaded with proteids and fats, they are assimilated by the cells of the Graafian follicle very readily, and intrafollicular pressure is increased. This produces excitement in the female, and during sexual

union she is more passionate and active and is more likely to reach orgasm, which ruptures the Graafian follicle and produces the best condition possible for male-production. "The bulk of the carbohydrate food reaches the liver as dextrose, or as dextrose and levulose, and these forms of sugar may be converted into glycogen in the liver cells by a simple process of dehydration" (Howell). A very small quantity of carbohydrates is stored in the muscular tissue which has a glycogenic function, as well as the liver, but this is consumed by the muscular tissue. It is the quantity stored up in the liver which is taken up by the blood and distributed to other tissues of the body slowly, uniformly, and just as it is needed. When starch is the principal food, it maintains a very regular and uniform blood-pressure; and the liver converts it into glycogen and stores it until needed by other tissues in the body. Such food creates a scarcity of protein in the blood, which retards to the minimum the production of fluid in the Graafian follicle. If the Graafian follicle reaches maturity very slowly, it fails to create the feminine passion, which it would do if developed more rapidly. When the blood-vessels are not so full of blood, the sexual organs are not so sensitive, and, during sexual union, orgasm is not so liable to be reached. In the latter case the Graafian follicle is not so liable to be ruptured as it would be if it had been matured rapidly and well filled with fluid, and if the blood-vessels of the ovary were well filled and distended.

5th Maternal Secondary Law.—Occupation.—Those who follow a regular occupation requiring active physical exercise, be it much or little, and maintaining their normal physical vigor, will ovulate at the normal time in

relation to menstruation. If, however, there is a lowered physical condition we may anticipate a delay proportionate to the lowered vitality. In case the occupation is discontinued, an early extrusion of the ovule may be anticipated for the following two or three months. This is caused by an increased flow of blood to the ovaries. In persons devoted to ease and pleasure, we may find a condition just contrary to what we would ordinarily expect. Instead of an early maturity of the ovule, we find delays caused by occasional overexertion, such as dancing associated with loss of sleep, going on extended trips, assuming the duty of cook or servant in the home, all of which must be considered. In those of regular habits, who do not place a strain on their physical power, and who lead a sedentary life, we may anticipate the maturity of the Graafian follicle a little earlier than normal: a day or probably a day and a half.

6th Maternal Secondary Law.—Age.—In the average nulliparous woman, of regular habits, vocation, and physical condition, at the age of twenty-four, ovulation will take place about midway between the cessation of one menstruation and the beginning of the following one. In those who menstruate every twenty-eight days, losing a normal quantity of blood for three days, the time for the maturation of the ovule and the ripened condition of the Graafian follicle would be at the end of twelve days and a half. Twelve hours may be deducted from this time for every year younger than the above-mentioned age, and six hours added for each year older. In multiparæ, where everything is equal to the conditions above described, we may anticipate the maturity of the Graafian follicle from two to three days sooner, for a

period of two years, which is due to the increased flow of blood to the parts.

The following cases are of interest: "Early in March, 1904, I attended Miss E. C., aged 50. She had passed 'the change,' and had seen nothing for just two years, when, deeming herself safe from the possibility of pregnancy, she ran the risk, and was duly delivered by me of a living male illegitimate child, nearly three years after having ceased to menstruate" (Dawson). Another somewhat similar case is recorded by Hann in a woman of 49 years, who gave birth to her thirteenth child—a boy—three years after the menopause; but in this case menstruation returned after the weaning of the child.

The sexual organs of a young woman are more tender and sensitive than those in later life; and, during coition they, as a rule, are more passionate and reach orgasm from less activity on the part of the male. This, in turn, ruptures the Graafian follicle when near maturity, and produces the best condition possible for male-production. Many of the older women become indifferent and impassionate, and remain in an apathetic condition during coition. When this is the case, the Graafian follicle is not ruptured during coition and the chance for male-production is at its lowest ebb.

When the production of a male child is desired, it is the duty of the husband and wife to produce the best child possible, one that will be a pleasure to them, a help to the community in which he resides, a star to his nation, and a light to the world. This can be done only by bringing the best and freshest male and female seed together in their most active state; to accomplish which the indulgence of pure, loving passion on the part of the

female is absolutely necessary, in order that she may reach orgasm during the sexual union, and this union must take place at the proper time.

To produce a female, the impassionate and apathetic condition on the part of the woman is as necessary as is the reverse condition for the production of a male, for the reason that the Graafian follicle must not be ruptured during the sexual union, but two or three days later when the spermatozoa have aged and become female-producing; then the follicle should rupture of its own accord. This insures fertilization by the best spermatozoön for female-production.

7th Maternal Secondary Law.—Climate in itself does not hasten or retard the maturity of the ovule in relation to menstruation, but a change of climate from a warm to a cold would hasten the maturation of the follicle possibly one or two days, and a change from a cold climate to a warmer one would retard the maturity about the same length of time. This change would not be effective for more than six months, after which the individual would become acclimated. Rarefied air, or a high altitude, will retard the maturation of the follicle one or two days in those not acclimated; descending into a heavy atmosphere will hasten the maturity one or two days. Going from a normal atmosphere into an abnormally moist one will retard the maturity of the follicle one or two days; going from a moist to a dry and more normal climate will produce the reverse condition.

8th Maternal Secondary Law.—Individual peculiarities.—In some of the best specimens of womanhood there is a production of female children all through life, and in others, on the other hand, there is an unbroken produc-

tion of male children. This is due, in the former, to early insemination after the cessation of the menstrual flow, before it is possible to rupture the Graafian follicle during the sexual union, the spermatozoa ascending into the Fallopian tubes and, after a day or two, becoming female-producing before the extrusion of the ovum from the Graafian follicle.

In the case of a chaste husband, the sex of the offspring is prone to be female, on account of the spermatozoa remaining in the vesiculæ seminales until they are old and female-producing. When a woman has been plethoric during her younger days, and afterward becomes anemic from any cause, this change produces a shrinkage of the ovary, causing the peritoneal covering to be more susceptible of distention. When this condition is present the maturation of the Graafian follicle is very indefinite, as the peritoneal covering yields to the protruding Graafian follicle. This condition varies, however, in different women and in the same woman in proportion to the anemic condition present. When a male child is desired in these cases, the woman should go on a meat-and-fat diet, using a small quantity of starch and a large quantity of water for a day or two before insemination. This will increase the bulk of the blood and thus aid in distending the ovary, so that, during orgasm, the ovum is more liable to extrusion. Where the ovarian and the ovarian branch of the uterine arteries are abnormally small, the Graafian follicle is matured slowly and late; if these arteries are large, the Graafian follicle is matured rapidly and early. The sexual passion is more marked in some women than in others; those who are passionate and those whose sexual organs are sensitive and tender,

as the blonde, the plethoric, the young, the experienced, and those who have borne children, are more likely to reach orgasm during sexual union than the apathetic, brunette, lean, anemic, old, inexperienced, and nulliparous. The mucous membrane of the blonde is very thin, tender, and sensitive. The sexual organs of the plethoric are more thoroughly filled and distended with blood, and the stretching of any mucous membrane renders it thinner, and more sensitive and tender to touch. The sexual organs of the young are more sensitive and tender than those of the older. The experienced woman understands how to bring herself to orgasm during the sexual union. Pregnancy produces an enlargement of all the blood-vessels to and from the sexual organs, and after delivery there is a greater flow of blood to these parts during sexual union than in the nullipara; this congestion renders the Graafian follicle more liable to rupture during sexual union. Where a long time has elapsed between parturition and renewed sexual union, the blood-vessels will have returned to their former condition. The sexual organs of the apathetic are not so well filled and distended with blood as those of the passionate, and orgasm is a thing unknown to them. The mucous membrane of the brunette is thicker and far less tender and sensitive than that of the blonde. The sexual organs of the lean and anemic are very slow to fill with blood and never reach the distention observed in the full-blooded or plethoric individual. The sexual organs of older women become less tender and less sensitive to touch, and increasingly so with advancing age. The inexperienced do not, and could not be expected to, reach orgasm during the sexual union. The blood-

vessels to and from the sexual organs of the nulliparous are smaller and are not so readily filled as those in women who have borne children.

All those who reach orgasm during the sexual union have the power to produce male children when insemination takes place at the proper time. It is a very difficult problem to make an exact calculation when the rupture of a Graafian follicle will take place, and for that reason it will be hard to control the production of sex in those who do not reach orgasm during the sexual union.

A Graafian follicle is not mature until it can be ruptured at the moment of orgasm, during the sexual union. Its rupture may be produced by orgasm from three to five days sooner than it would if allowed to rupture of its own accord. In some cases it will not rupture at all without orgasm, as is beautifully illustrated in the case of Abraham and his wife Sarah. It seems that Abraham was unable to bring Sarah to orgasm and rupture a Graafian follicle, until three months after he had been circumcised, when he produced his son Isaac.

9th Maternal Secondary Law.—Copulation.—Nature has designed that rupture of the Graafian follicle should take place at the moment of orgasm, during coition. During coition the female generative organs become filled and distended with blood. At the moment of orgasm there is a rigid contraction of all the plain muscular fibres which enter into the composition of the vagina and uterus, cutting off the arterial flow of blood to these parts and increasing the quantity of blood-flow to the ovarian branch of the uterine artery. At the same time this contraction causes a rush of venous blood from the vagina and uterus, filling and distending the

uterine venous plexus with blood, and it is more than probable that there is a rush of blood through the ovarian veins, causing a considerable, if not a total, obstruction, for a few moments, to the exit of venous blood from the ovaries. Furthermore, according to Schäfer, there is a large number of plain muscular fibres in the stroma of the ovary near its attachment to the broad ligament. Contraction of these fibres prevents escape of blood from the ovary, while it would not materially retard the arterial flow to it. The control of these muscular fibres is most sure to be affected by sexual shock, orgasm producing their contraction. The above conditions, augmented by the contraction of the abdominal walls, would give considerable impetus to the rupture of the Graafian follicle. For this reason it is so essential that the woman should reach orgasm during the sexual union, when the production of a boy is desired. That rupture of the Graafian follicle is simultaneous with orgasm is conceded by Edgar, when he states that it "makes conception more probable." Therefore coition in the female is absolutely contra-indicated where we desire to control the production of sex, except at the time for insemination which should be carefully selected in advance. There should be no vaginal douche used during the day of insemination nor the day following, since it is liable to injure the spermatozoa and by so doing produce a weakened condition of any part or the entire body of the offspring. Therefore it is unquestionably contra-indicated at this time.

PATERNAL SECONDARY LAWS.

1st Paternal Secondary Law.—Physical condition of the testicles, spermatic cords, vesiculæ seminales, and the secretions of the glands which pour their contents into the convoluted seminiferous tubules, vasa recta, rete vasculosum, vasa efferentia, convoluted canal of the epididymis, vas deferens, and the urethra.—The production of male or female offspring depends very much upon the physical condition of the testicles and the tubes and the medium through which the spermatozoa pass to the vesiculæ seminales, and of that part of the urethra through which the spermatozoa pass to the external os of the uterus, and of the secretions of the glands which pour their secretion into the passage-way of the spermatozoa. A normal condition of all the parts as enumerated is conducive to male-production; on the other hand, where we find a lax, flabby, and yielding testicle and a dilated and enlarged epididymis and spermatic cord, or any obstruction internally or externally, acting as an impediment to the progress of the spermatozoa, there will be a tendency to sterility or female-production.

2d Paternal Secondary Law.—Food, its quantity and quality.—A nitrogenous diet produces a rapid spermatogenesis, with consequent tenderness and small nucleus of the cells as explained on page 97. Where a carbohydrate diet is used the spermatozoa are produced slowly and there is a tendency to the elaboration of the best specimens in both size and quality. The best spermatozoa are produced while the male is on a constant and well-regulated diet, with just enough of the carbohydrates and a very small quantity of the proteids. Such

a diet produces large spermatozoa of great stamina. The consumption of a large quantity of the nitrogenous foods increases the bulk of blood, and the plethora renders the glans penis more sensitive to touch, so that less activity on the part of the male is necessary to eject the seminal fluid.

3d Paternal Secondary Law.—An individual of great vitality may transmit that quality to his offspring; first, by the primordial-germ vitality; second, by a prolonged time afforded for maturation at the period when a pause in cell division intervenes between the spermatogonium and the spermatocyte, since a lengthened interval allows perfect development of all the structures appertaining to a spermatocyte; third, by the mother cell retaining the spermatozoa in contact until they have received a full supply of the chromatic and other elements necessary for the production of a similar individual. Or, in other words, where we desire to produce a fine specimen of humanity, it is absolutely necessary to build up the spermatozoa slowly from the primordial germ-cell to the spermatozoön, and this is done by slow spermatogenesis. This condition may be favored by hard physical labor, and a constant supply of carbohydrate food, with a very small quantity of proteids. Where there is a full supply of the protoplasm stored in the nucleus of the spermatozoa, the male-producing quality is increased proportionately. The sex-production of the spermatozoa from an individual of great vitality is controlled by the primary law.

4th Paternal Secondary Law—Age.—The age of the male plays a very important part in sex-production, and may be considered under the following heads: physical

condition of the spermatozoa; size of the vesiculæ seminales; the sensitiveness of the glans penis; and the power of the individual for sexual union.

The spermatozoa of the young man are more tender and delicate, and the nucleus is not so large and well filled, owing to the rapid spermatogenesis; the nurse cell is forced to take care of its maximum number—from twelve to twenty. On the other hand, in the older individual the spermatogenesis is not so rapid; the nurse cells accommodate the minimum number of spermatozoa—from four to eight. They thus obtain more food, more room, more time to mature in, and their vitality is greater, hence these spermatozoa retain the male-producing quality longer.

The size and shape of the vesiculæ seminales play a considerable rôle in sex control. In a male child at birth, the convoluted seminiferous tubules are represented by a single row of cells, like a string of beads; their growth is very slow and they are ultimately developed into a solid tube which has no lumen until puberty approaches, when the lumen opens to transmit the spermatozoa and the secretions of the tubules. At about the time of puberty, when the lumen has opened and the seminal secretion begins to flow into the spermatic cord and the vesiculæ seminales become filled, the sensitive nervous mechanism will not permit a great deal of dilatation at first. If the semen is not ejected voluntarily the sensitive nervous mechanism takes advantage of the individual while he is asleep and throws it off, and this condition continues for five or ten years and in some individuals longer, until the vesiculæ seminales have been fully developed and dilated. At this time the

vesiculæ seminales are in a mature condition, the nervous mechanism is not so sensitive, the tunics have been dilated and distended until they will hold a full normal quantity of the seminal fluid which is retained without discomfort. The individual can now go to sleep without fear of the nervous mechanism taking advantage of his slumber to eject the contents of the vesiculæ seminales. Thus, we can easily understand why the spermatozoa will age readily in the older individual and become female-producing. Where it is desirable to produce a male child from an old individual, the contents of the vesiculæ seminales should be ejected at least once a day for three or four days prior to insemination. This will make it certain that all the spermatozoa are young and male-producing.

The sensitiveness of the glans penis varies in different individuals, and in the same individual at different times. The glans penis is more sensitive and tender in the blond than in the brunette; in the plethoric or full-blooded than in the anemic and lean; in the chaste than in the unchaste; in the young than in the old; in those with long prepuce than those with short prepuce; in the uncircumcised than in the circumcised. The blond, plethoric or full-blooded, chaste, young, those with long prepuce and the uncircumcised, all belong to the female-producing class. The brunette, lean, those who are unchaste, old, those with short prepuce and the circumcised, all belong to the male-producing class. The glans penis of the blond is covered with a very thin, delicate mucous membrane. In the plethoric there is a greater distention of the glans penis during erection. The vesiculæ seminales of the chaste are usually filled with semen—a condition

which produces a hyperæsthetic condition of the glans penis. The sexual organs of the young male are far more tender and sensitive than those of the older man. The uncircumcised and those with long prepuce have very tender and sensitive sexual organs. Very many of these classes of men eject the seminal fluid immediately after penetration, before the female has experienced any degree of shock from the sexual union. In such a case there is very little chance to control sex-production, unless a female child is desired, when these conditions are ideal.

The glans penis of a brunette is covered with a thick mucous membrane which is less sensitive to touch than that of a blond. The glans penis of a lean man with little blood is not filled and distended as is that of the plethoric, and hence the organ is less sensitive. The vesiculæ seminales are practically always empty in those who are unchaste, in which event the glans penis is far less sensitive to touch, and more activity on the part of the male is necessary to eject the semen. The glans penis of the older man is less sensitive to touch, and requires more activity on his part to eject the semen. When the prepuce is short and for any reason fails to cover the glans penis, it remains dry, is subject to thermal changes, and its rubbing against the rough clothing causes a growth of very thick mucous membrane which is far less sensitive to touch than when the glans is covered—a condition which is similar to that in the circumcised, as explained in the primary law (page 190). All such men are far more capable of bringing the female to orgasm than those above described, and it is these men who should be able to control the sex of their children. All of the male sexual organs—the testicles, the tubes through which

the spermatozoa pass, the spermatic cord, the vesiculæ seminales, the penis, and all the accessory glands—must be in a normal condition before one can hope for the control of the sex of the children.

5th Paternal Secondary Law.—Occupation.—All those who constantly and continually exercise all the muscles in their body, who work hard and labor long, who do a reasonable amount of brain work and take just enough food to prevent any accumulation of fat, will augment the production of highly vital and large spermatozoa. Men who live an inactive life are prone to rapid spermatogenesis, which produces a delicate spermatozoön with small nucleus. Those who follow an occupation which causes compression of the testicles, such as horseback riding, shoeing horses, and wearing very tight clothing about the loins, are liable to produce weak, delicate male children. Compression of the testicles causes the separation of the spermatozoa from their mother cells before they are fully matured. This renders them male-producing owing to their very rapid movements. The spermatozoön, when prematurely detached from its mother cell, is very rapid in its movements, and is thus enabled to lacerate the vitelline membrane of the ovum and pass through into the cytoplasm, carrying with it the sex-membrane, body, and tail, producing a male. In such a case a male is produced by the rapidity of the movement of the spermatozoön and not by the large size of its nucleus, though as a rule it is necessary in male-production that the nucleus be large or that great activity be displayed on the part of the spermatozoön. It is impossible to produce a female unless the nucleus is more than half covered by the sex-membrane and the move-

ment of the spermatozoön is rather slow, and this is the reason why the female is uniformly smaller than the male.

6th Paternal Secondary Law.—Clothing about the loins.—The protection of the testicle by clothing is one of the evils of our civilization, for just in proportion as these organs are protected, will tenderness and delicacy be transmitted to our offspring. The explanation is found in the warmth which increases the blood-flow to the parts by dilatation of the blood-vessels and more or less relaxation of all the tissues which enter into the composition of the testicles and their tunics. Relaxation and dilatation of the blood-vessels hasten puberty and bring on a rapid production of spermatozoa, both of which conditions are conducive to delicacy in the offspring. The clothing about the testicles should be both thin and loose. Keeping the testicles cool quickens the circulation and brings about a healthy state of these organs and the tunics. Tight clothing exerts pressure upon the testicles and causes detachment of the spermatozoa from their mother cells prior to their full development. When spermatozoa are prematurely detached they are for a short time more active than those more fully developed and it is to the prematurely detached cells that the greater mortality of male children is due.

7th Paternal Secondary Law.—Copulation.—A moderate indulgence in coition during early manhood will serve to prevent an overdistention and a permanent enlargement of the vesiculæ seminales. Indulgence in excess produces rapid spermatogenesis which renders the nuclei of the spermatozoa small, and they soon become female-producing. Where the production of a male child is desired the vesiculæ seminales should be emptied

at least twice a week for two or three weeks, and once a day for three days prior to insemination. The last emission should take place one day before the insemination. Where it is desired to produce a female the spermatozoa should be retained in the vesiculæ seminales at least five days before insemination.

8th Paternal Secondary Law.—Puberty.—When puberty is established early in life a hastened development and dilatation of the vesiculæ seminales will result. Early advancement to puberty produces rapid spermatogenesis.

9th Paternal Secondary Law.—Climate and altitude.—The change from a warm to a cold climate or from a dense atmosphere to a lighter one will cause very little difference in the size and quality of the spermatozoa produced. Those who live in a warm or tropical climate will advance to manhood sooner than those who live in a temperate climate and their lives will be shorter.

CHAPTER X.

FINAL INSTRUCTIONS.

Male-Production.—The spermatozoön must reach the ovum before it becomes old and female-producing. To do this it is necessary to inseminate at a time when orgasm of the female will rupture the Graafian follicle. Orgasm in the female will probably rupture a follicle from three to five days sooner than it would if allowed to burst of its own accord. To produce a male in a normal woman, fourteen days from the last day of menstruation should be elected for the date of insemination. It is better not to cohabit after the election date of insemination, inasmuch as orgasm of the female is liable to expel the fertilized ovum before it has become attached to the wall of the uterus. If cohabitation is to follow, it should not begin sooner than three or four days and not continued longer than to within three days of the anticipated menstruation. It is not known how long after insemination a spermatozoön is capable of fertilizing an ovum. It depends on how well developed it is when it leaves the mother cell (cell of Sertoli), how long it is in reaching the vagina, and the medium to which it has been subjected. It is probable that the best of the spermatozoa are capable of fertilizing an ovum from two to five days after insemination. If a woman fails to become pregnant for six months after observing the instructions as above given, then elect a date twelve days after the menstrual flow and continue that for eight

months. Then if conception has not taken place, a still shorter period of ten days after menstruation should be elected, and this be repeated for twelve months. If the woman still fails to conceive, a shorter period of eight days after the flow should be elected for insemination, and repeated four months; then, if conception has not taken place, a shorter period of six days after the flow should be elected for insemination. This will undoubtedly include all those who mature the Graafian follicle very early after menstruation. For male-production rupture of the Graafian follicle during insemination is imperative and the greatest stimulus to its rupture is orgasm during the sexual union, which may be augmented by the woman going on a proteid diet and drinking an abundance of milk and water or any fluid except those containing alcoholic stimulants, such as wine, champagne, beer, ale, or whisky. These must not be used in any quantity by the female. After insemination she should lie for three or four hours on the side of the ovary which matured the ovum; if it is not known which ovary matured the ovum, she should choose the most comfortable side to lie on and remain on that side for five or six hours to assist by gravity the ovum to the fimbriated extremity of the Fallopian tube, where it can be taken in by the ciliated epithelium and delivered to the spermatozoa in the Fallopian tube. The above instructions are for those women who are in a normal condition. If anything unusual presents itself which would delay maturity of the follicle, due allowance must be made for it as indicated in the secondary laws. I furthermore state that the loss of blood from any cause—diarrhœa, hydragogue cathartics, scarcity of proteids in the diet, illness of any kind,

overwork, great grief or joy—will delay the maturity of the Graafian follicle. To prepare the male for the production of a fine male child, he should go on a starch diet for two or three months prior to the anticipated insemination, work hard and constantly, remain secluded from the female, see that the clothing is loose about the testicles and that they are not subjected to any pressure just five or six days before the anticipated date of insemination. The semen should be ejected once each day for four or five days before insemination. This will insure the presence of the very best specimens of spermatozoa and at the same time require more activity on the part of the male to reach orgasm and will assist the female to orgasm. If the male has a hyperæsthetic glans penis, this may be counteracted by circumcision or by the use of an alcoholic stimulant just before insemination. The male should abstain from the use of an excessive quantity of fluid or drink just prior to insemination. The female must not allow sexual union from the last day of the menstrual flow until the date elected for insemination, as it would be liable to rupture the Graafian follicle, and propulsion of the ovum to the vagina would follow. Pregnancy always increases the size of the blood-vessels to the generative organs—to the ovaries—and they will mature the Graafian follicles sooner after the menstrual flow for a period of two or three years.

Female-Production.—Insemination may follow the cessation of the menstrual flow until five days after it, when it must cease until sixteen days after the last day of the menstrual flow. Orgasm of the female must not take place in any sexual union from the last day of the menstrual flow to the fifth day following. An alco-

holic stimulant, such as wine, whisky, champagne, beer, or ale, taken just before insemination will prevent orgasm on her part. The male, in this case, must abstain from any alcoholic beverage and the use of a good quantity of proteids may be advised for a day or two before insemination as this will hasten orgasm. A starch diet should be used for two months or at least six weeks before insemination, when a fine, healthy, stout child is desired, and it is the duty of a father to devote as much attention to the production of a daughter as to that of a son.

The sex of any one animal belonging to the mammalian group may be controlled by bringing fresh spermatozoa (from Sertoli cell) to the ovum, at a time when the Graafian follicle is ruptured. This is almost without exception several days after œstrum has been inaugurated.

Control of Sex in the Class Aves or Bird Family.—When the production of males is desired, the female should have begun laying before mating. Mating must not be allowed for thirty days prior to the selected date. This eliminates all chances of a previous fertilization of the eggs. Mate with an active cock in the prime of life, one which has had access to females for several days previous to mating; this insures the presence of active male-producing spermatozoa in the vesiculæ seminales. The first eggs laid after such mating are very valuable, inasmuch as the birds produced from them are far superior to those from eggs laid later. The eggs laid the second day after mating are fertilized.

It may be desirable to control the sex in birds which lay two or three eggs for a setting. This can be done by

removing the eggs from the nest each day, allowing only one to remain in the nest; by so doing the bird will lay for an indefinite time. The production of eggs is controlled by the bird's diet; when she sets she refuses food and drink to the extent that the production of eggs ceases. This condition renders it possible to control the sex in the bird family.

A bird seldom begins to set before she has her appropriate number of eggs, which is the number of young she is capable of taking care of.

The production of female birds is more difficult. In this case the male must not be allowed to mate other females for three weeks prior to mating the female in question. The female should not be mated until she is ready to lay, and then be permitted only three or four matings in one day, with a male which has not mated for three weeks. This insures the presence of female-producing spermatozoa in the vesiculæ seminales and spermatic cord. The cock should be past the prime of life, and rather inactive. A cock in this condition will produce at least eighty per cent of female offspring from the first four females mated. The first three or four eggs from each female bird so fertilized will produce birds far superior to those from eggs laid later. To improve the stock of birds, this method of selection will be found superior to any advanced heretofore.

Control of Sex in the Reptile Family.—The general anatomy and physical condition of reptiles are so closely related to those of birds that we may use the same methods to control sex in them, as above given for birds.

Control of Sex in the Fish Family.—In the case of fish that are produced from the ova and spermatozoa

which are brought together by the intervention of man, the sex may be controlled very readily.

Males can be produced by placing both ova and spermatozoa in water at such a temperature that fertilization may be hastened. This will insure the preponderance of males.

Females can be produced by subjecting the spermatozoa to water at a temperature in which fertilization would take place and allowing them to remain until the nucleus is smaller in diameter than that of the sex-membrane; then introduce the ova into the water, and all eggs will produce females. To determine the time required, it will be necessary to examine the spermatozoa with a microscope. Some spermatozoa become female-producing much sooner than others, and the temperature of the water in which the spermatozoa are kept will play its rôle in female-production.

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